Technical Addendum:
2011 Sample Results and Discussion

Addendum to the "Technical Memorandum: An Analysis of Nutrients and Select Metals Within Wastewater from Greenhouse Operations in and Around Leamington Ontario"

2011 Greenhouse Sample results

In 2011, the Ministry of the Environment Southwestern Regional Office completed a second round of sampling of greenhouse outfalls in and around Leamington and Kingsville, Ontario. The purpose of the sampling work was to further identify potential sources of nutrient enrichment for watercourses in the area. A total of 12 direct outfalls were sampled in 2011 that were not sampled in the 2010 study. In addition to these 12 direct outfall sites, samples were taken from one municipal drain that services several greenhouse lots (Morse Drain – Site 9), and for comparative purposes, samples were taken from one subdivision stormwater control pond. For outfalls that were directly discharging into a running watercourse, samples were taken upstream and downstream of the outfall to evaluate impact to the receiving watercourse (these sites are 1, 2, 4, 5 and 7). The sample dates were May 25, June 27, July 20 and August 30 of 2011. Sample locations were along the following drains;

- Reid Drain (sites 2, 2a)
- Wallace/Fox Drain (sites 5, 11)
- Scratch/Wigle Drain (site 4)
- Sebele Drain (site 10)
- Hooker Drain (site 1)
- Second Conc. Rd Drain (sites 6, 6A, 8, 12)
- Morse Drain (site 9)
- Sturgeon Creek (site7)

Main Results

The sample results for 2011 were, for the most part, comparable to results obtained in 2010. In calculating the averages shown in Figure 1, the sample showing the heaviest impact from each site was excluded, in order to allow a conservative interpretation of the data. As in 2010, levels of macronutrients (nitrogen, phosphorus, potassium) and typical metal micronutrients (zinc, copper, manganese, iron and molybdenum - common to commercial fertilizer blends) were consistently elevated as compared to what would be considered normal background stormwater discharge. Nine of the twelve sampled sites demonstrated elevated levels of nutrients over what would be expected from typical stormwater ponds. 6 of the 12 sites demonstrated significant contributions of phosphorous to the environment (sites 1, 2, 5, 6, 11, 12).

Other Notable Results

Sites 1 and 2 show demonstrative deterioration of water quality with respect to nutrients at the sites that discharge directly into a flowing watercourse.

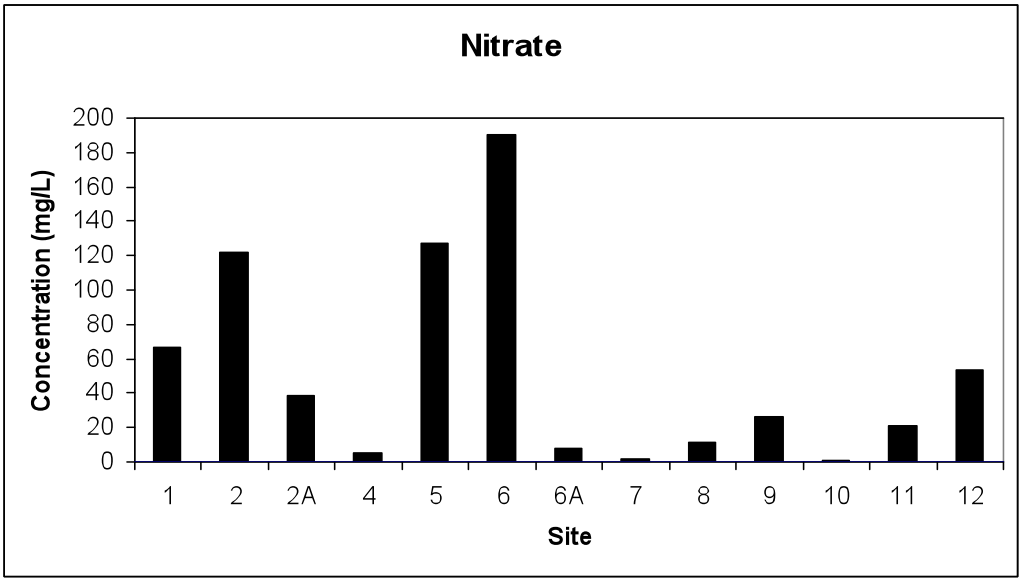
Sites 6, 8, 11 and 12 discharge directly into a drainage channel. The nutrient concentrations of the discharge are consistent with levels that would result in downstream impacts. An upstream sampling location was unavailable, so the extent of degradation to the watercourse could not be quantified.

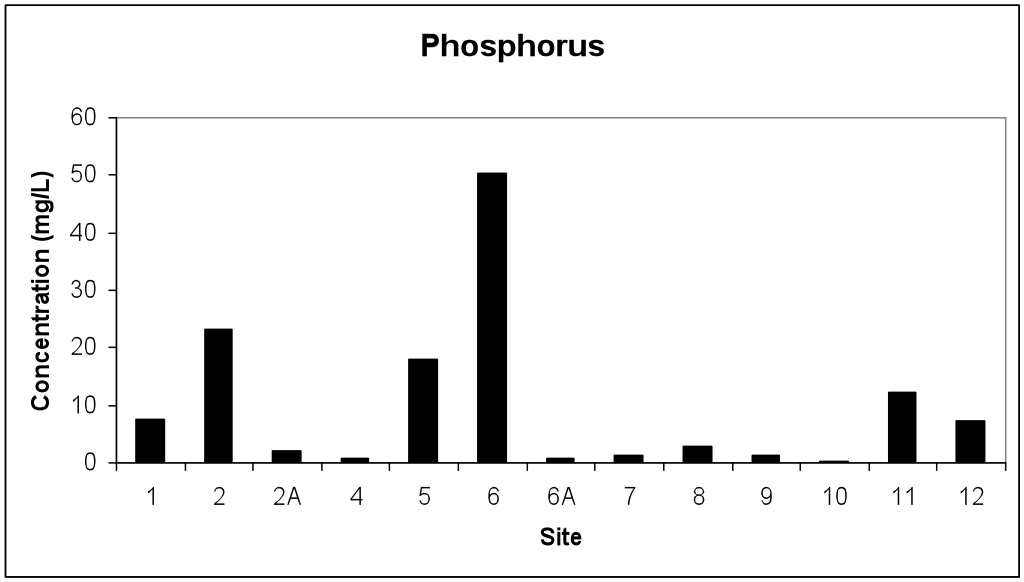
The Morse Drain was sampled downstream of a series of greenhouse buildings for which an outfall could not be located. Water quality results suggest a source of nutrient rich water is being added to the Drain.

Sites 4, 6A, and 7 have only slightly elevated levels of nutrients as compared to the other sites sampled and site 10 does not appear to have any nutrients present in the discharge water sampled.

Figures 2 through 14 graphically show results for the 2011 sample program. The control site has been added against each outfall for comparative purposes.

Raw sample data is presented at the end of the figures.





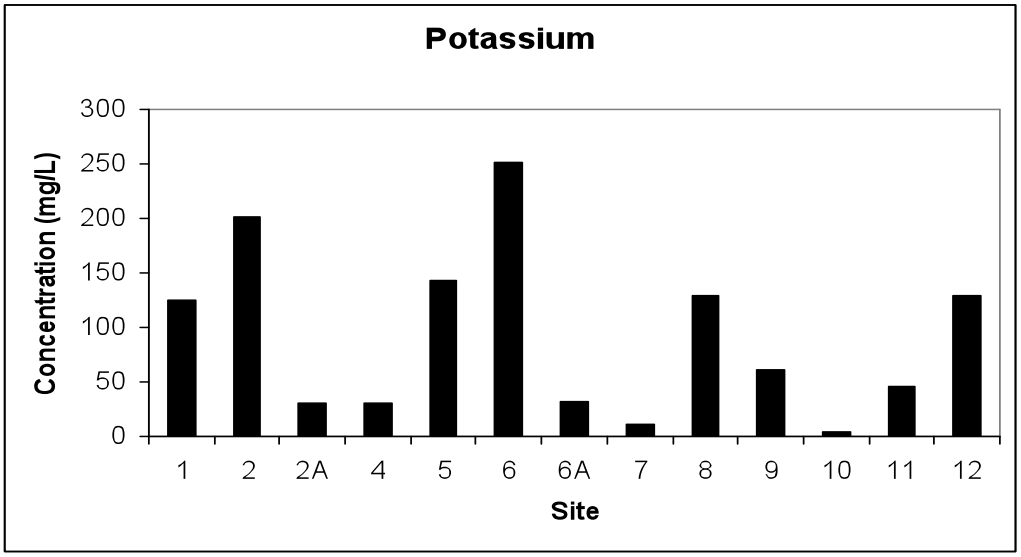
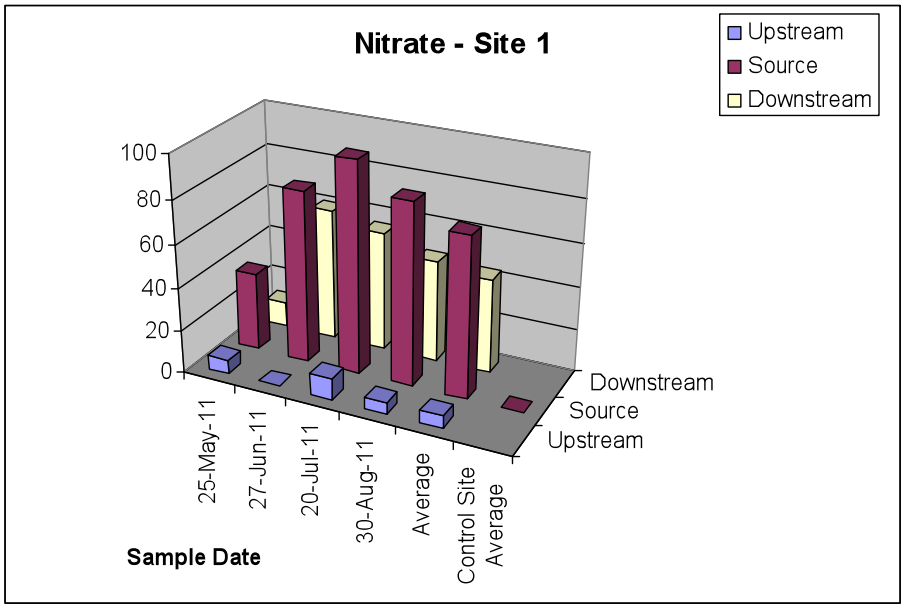


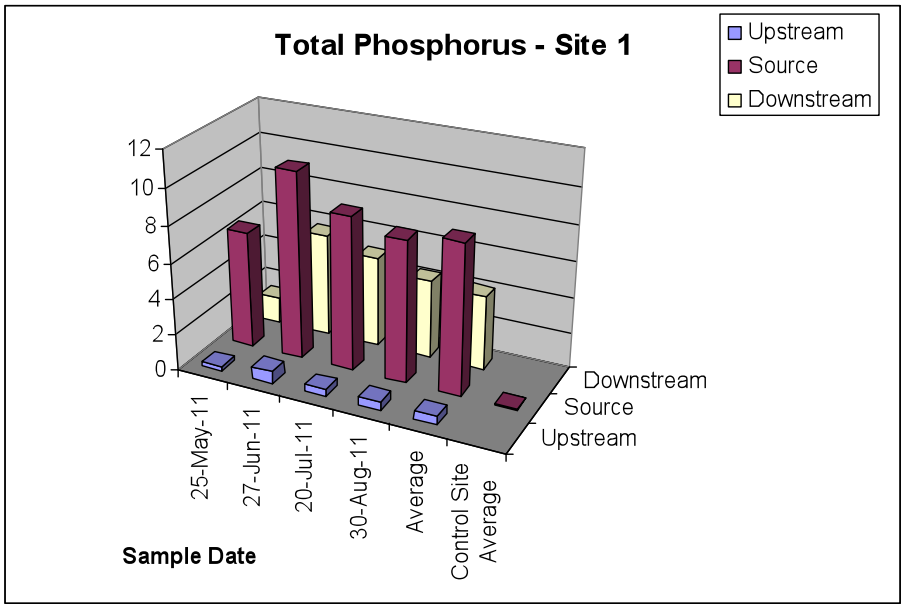
Figure 1:
Concentrations of nitrate, phosphorus, and potassium at each sampling site

Concentrations are expressed as an average of the concentrations found on the four sampling days (excluding the maximum concentration).

The control point concentrations are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





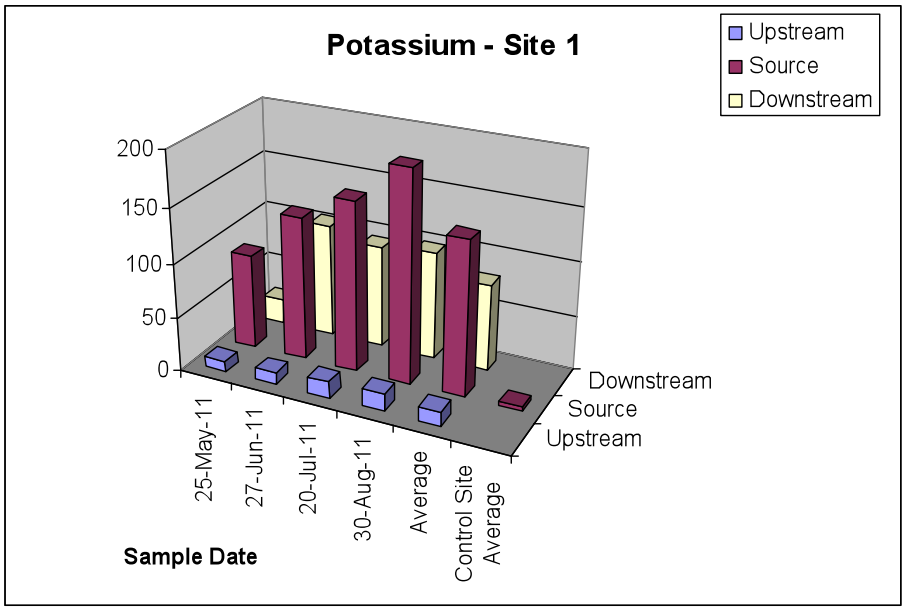
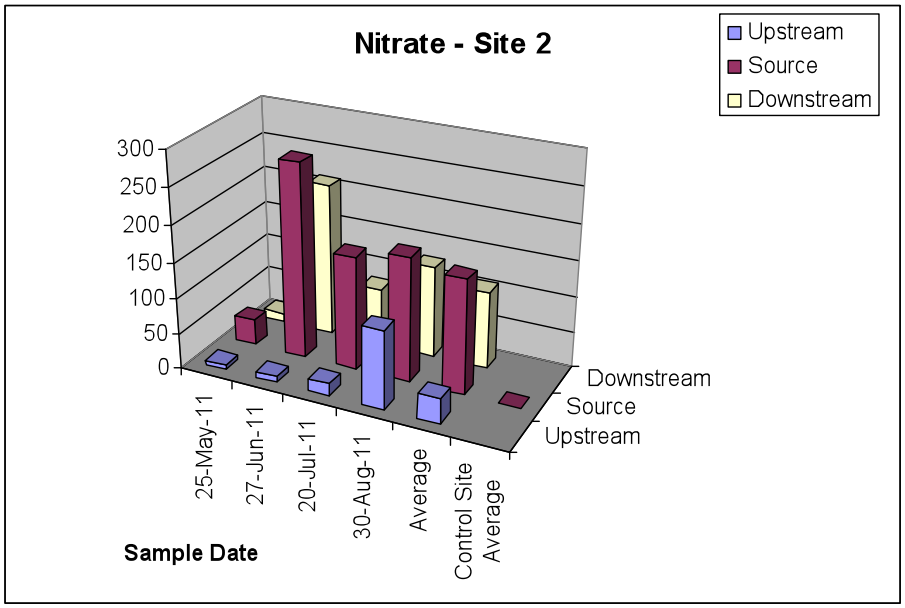


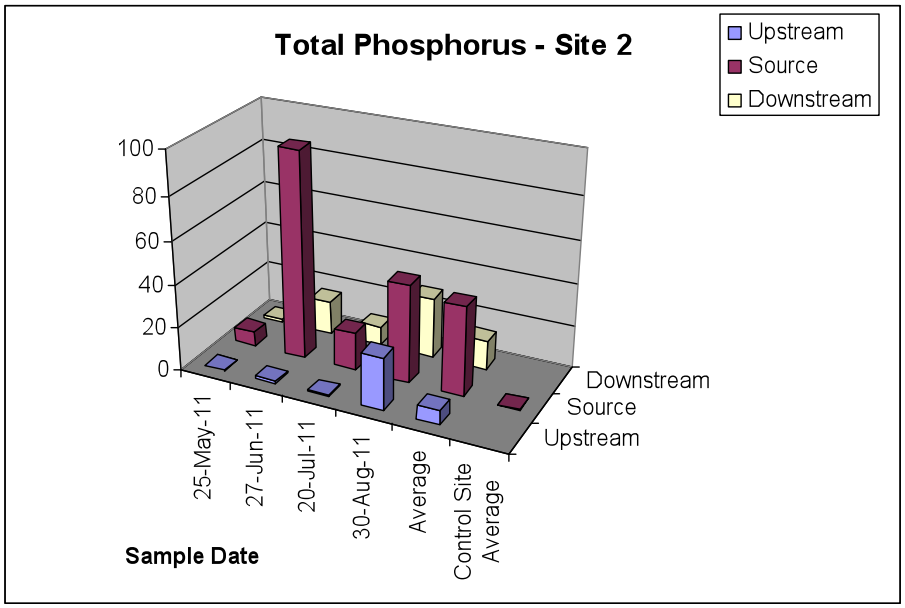
Figure 2: Nitrate, total phosphorus, and potassium concentrations at Site 1 on each of the four sampling days.

Samples were taken upstream, downstream, and at the source point. Shown also is the concentration at the upstream, source, and downstream locations averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





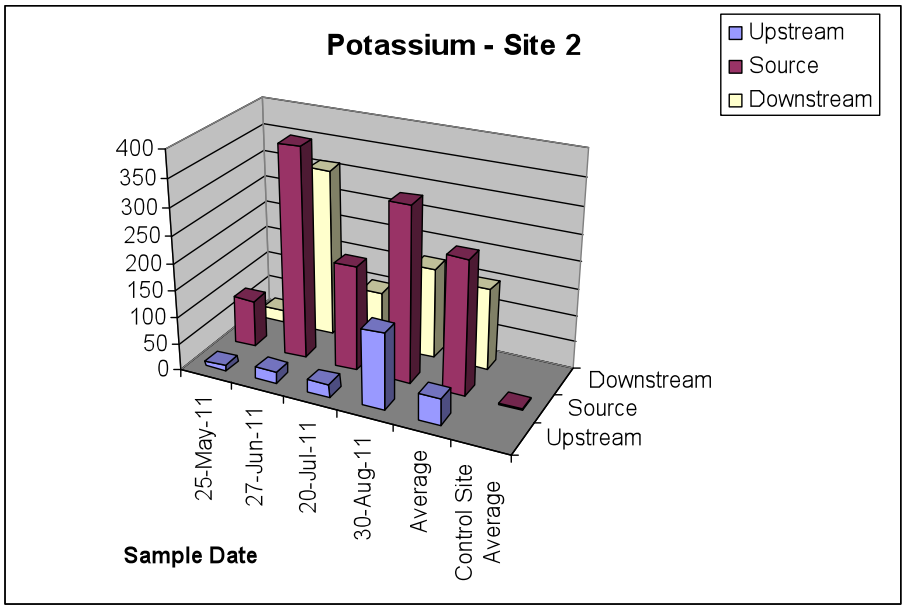
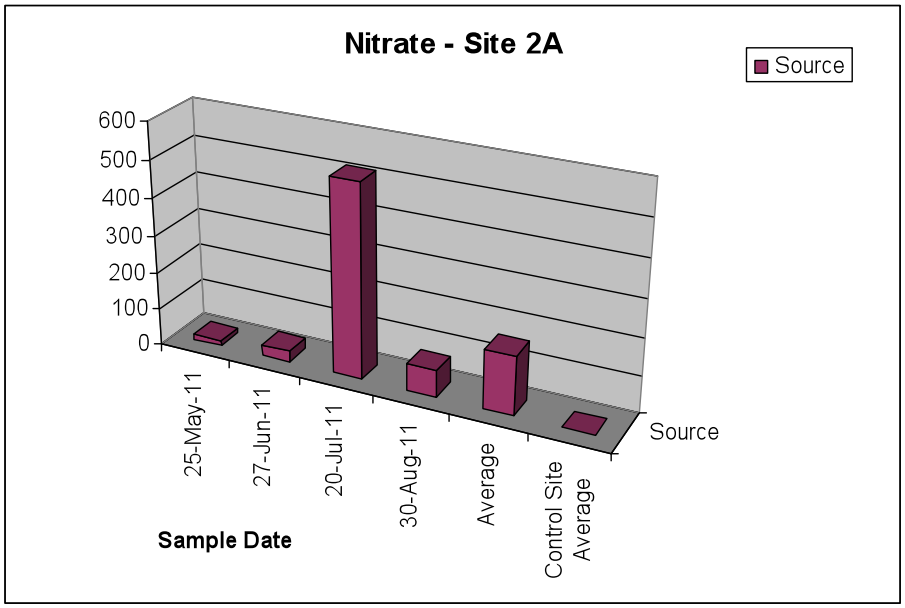


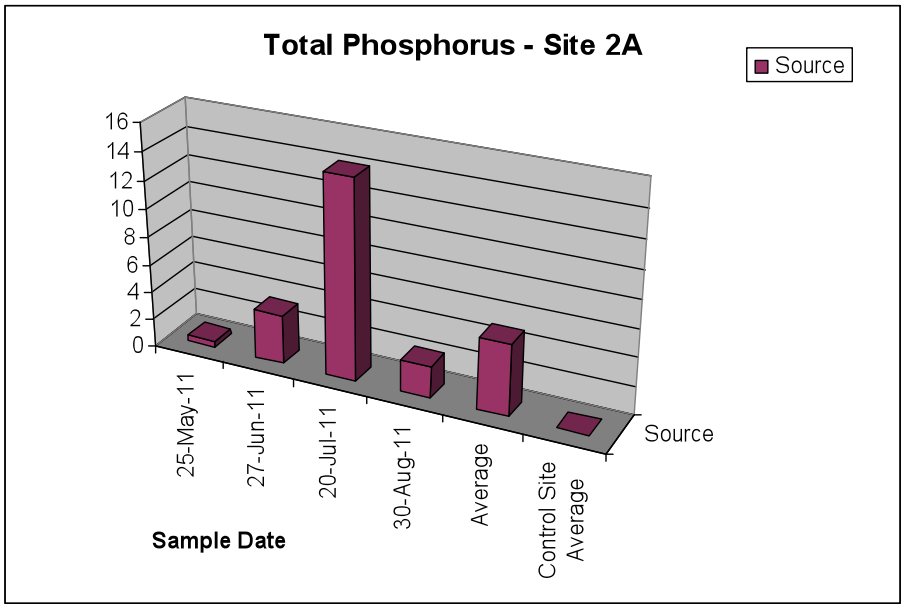
Figure 3: Nitrate, total phosphorus, and potassium concentrations at Site 2 on each of the four sampling days.

Samples were taken upstream, downstream, and at the source point. Shown also is the concentration at the upstream, source, and downstream locations averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





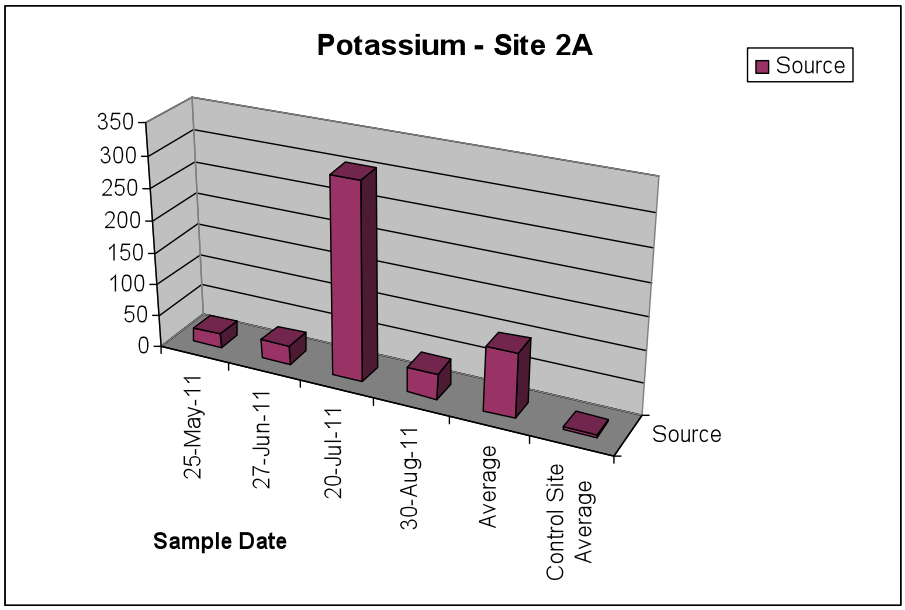
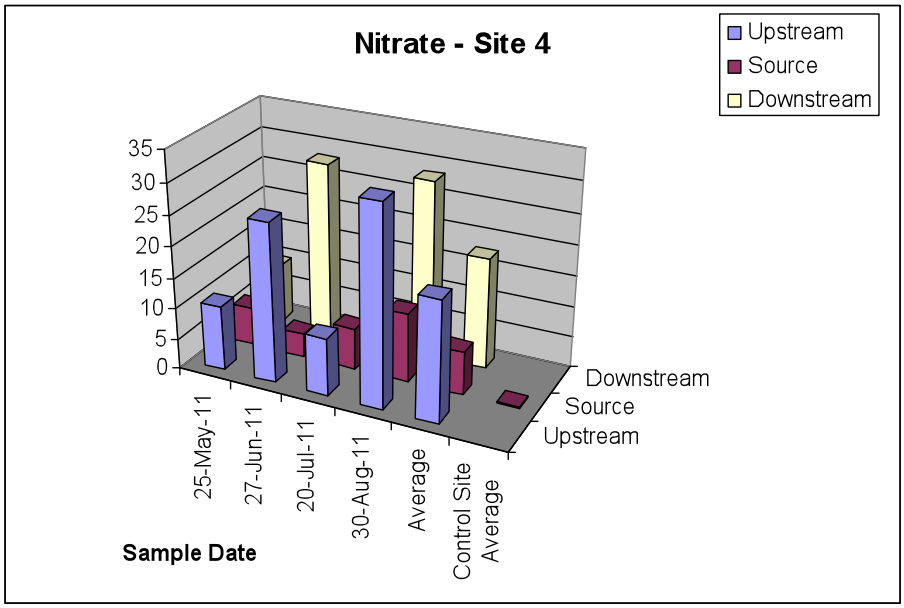


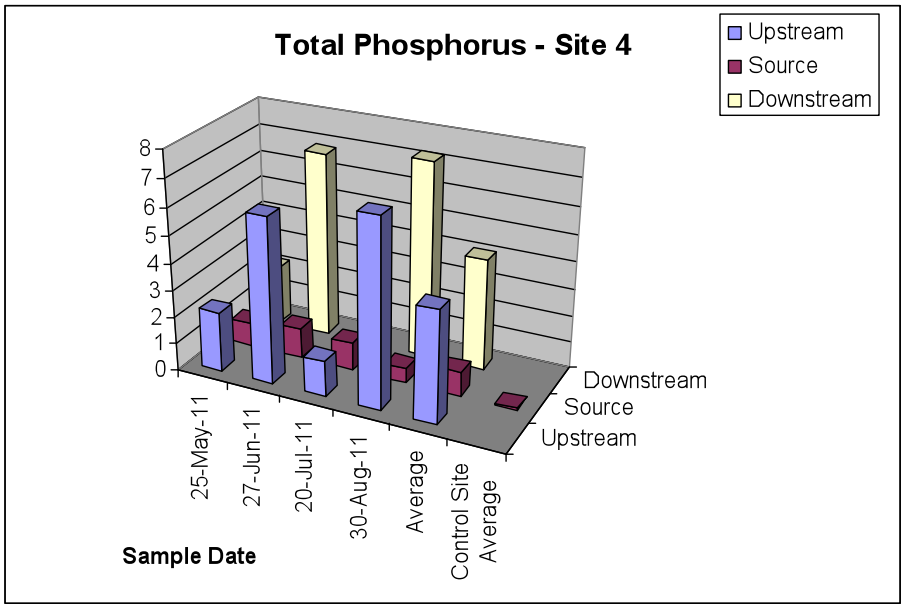
Figure 4: Nitrate, total phosphorus, and potassium concentrations at Site 2A on each of the four sampling days.

Samples were taken at the source only. Also shown is the concentration at the source averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





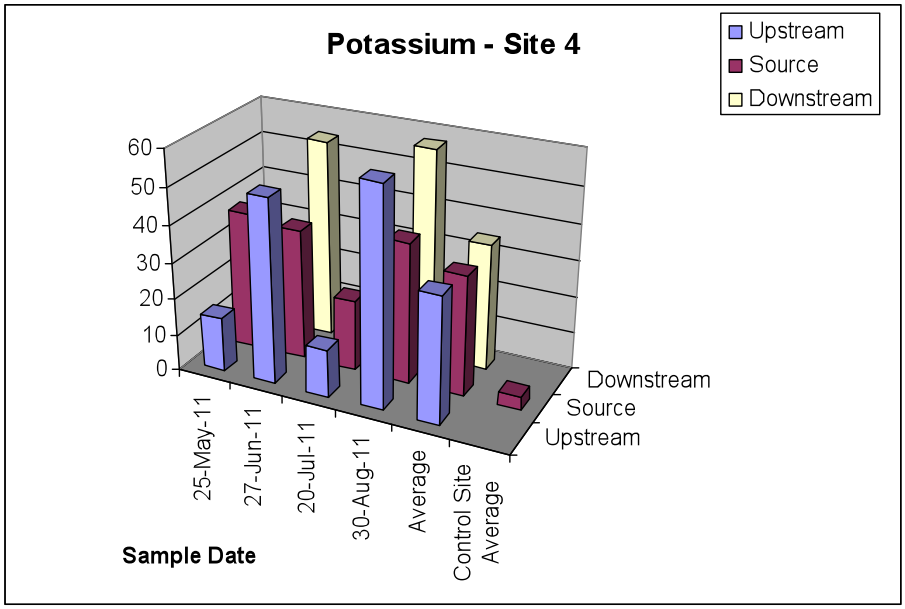
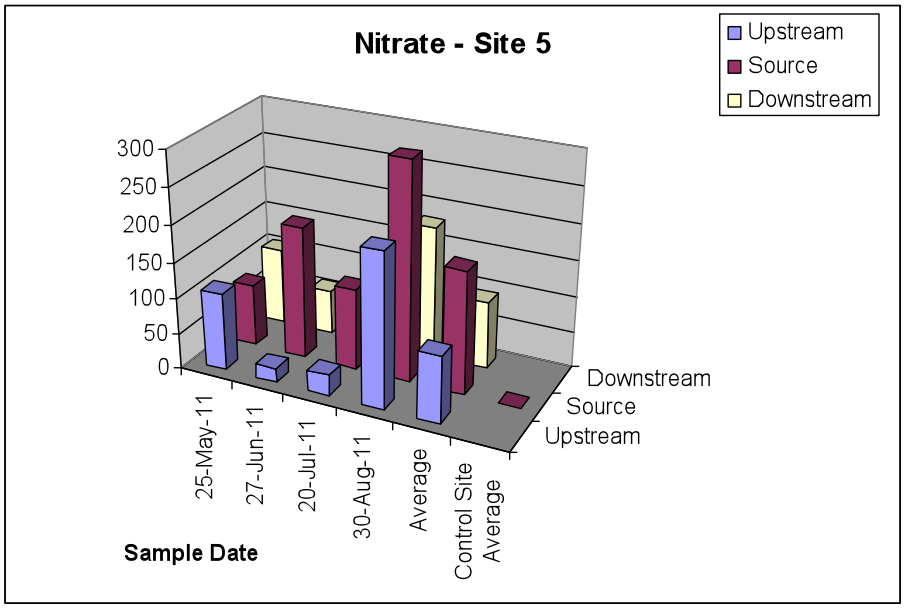


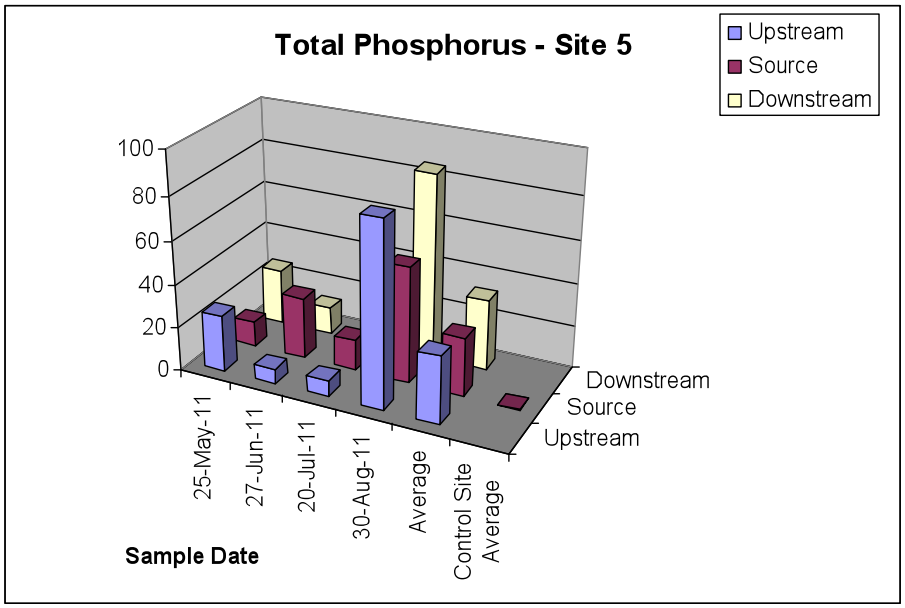
Figure 5: Nitrate, total phosphorus, and potassium concentrations at Site 4 on each of the four sampling days.

Samples were taken upstream, downstream, and at the source point. Shown also is the concentration at the upstream, source, and downstream locations averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





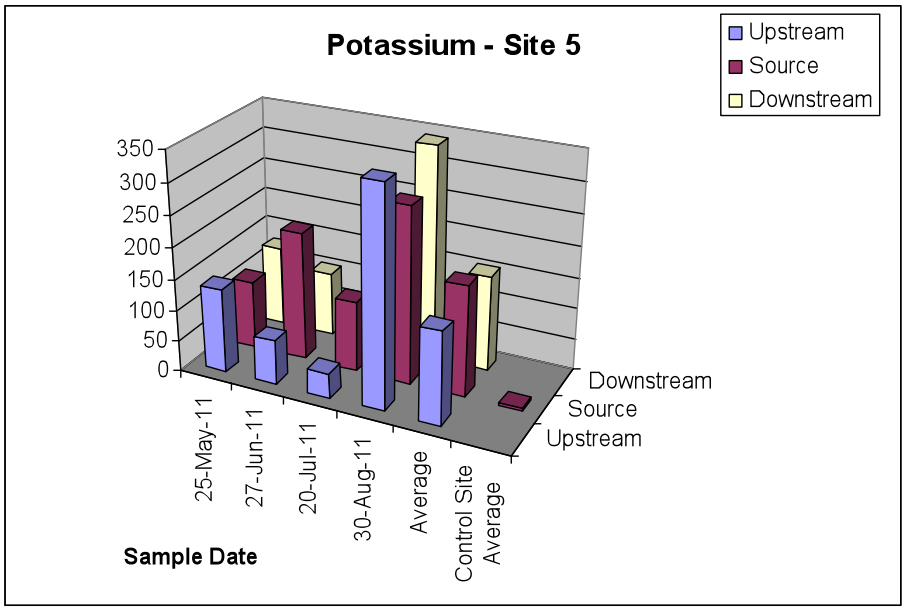
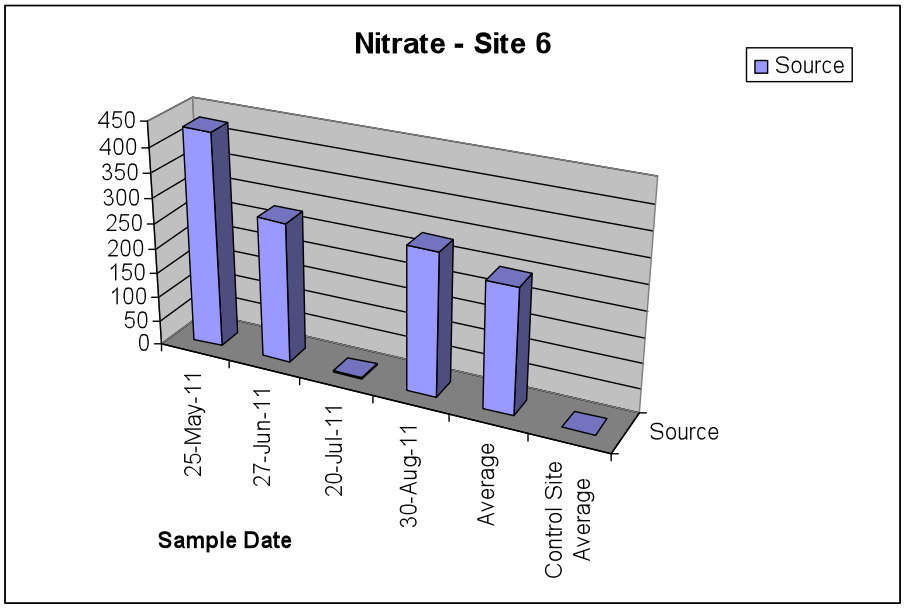


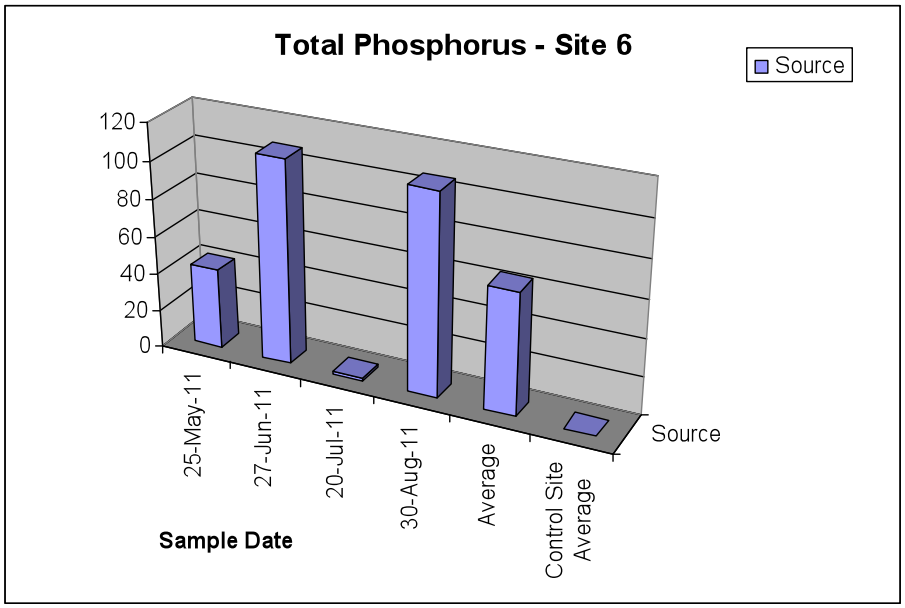
Figure 6: Nitrate, total phosphorus, and potassium concentrations at Site 5 on each of the four sampling days.

Samples were taken upstream, downstream, and at the source point. Shown also is the concentration at the upstream, source, and downstream locations averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





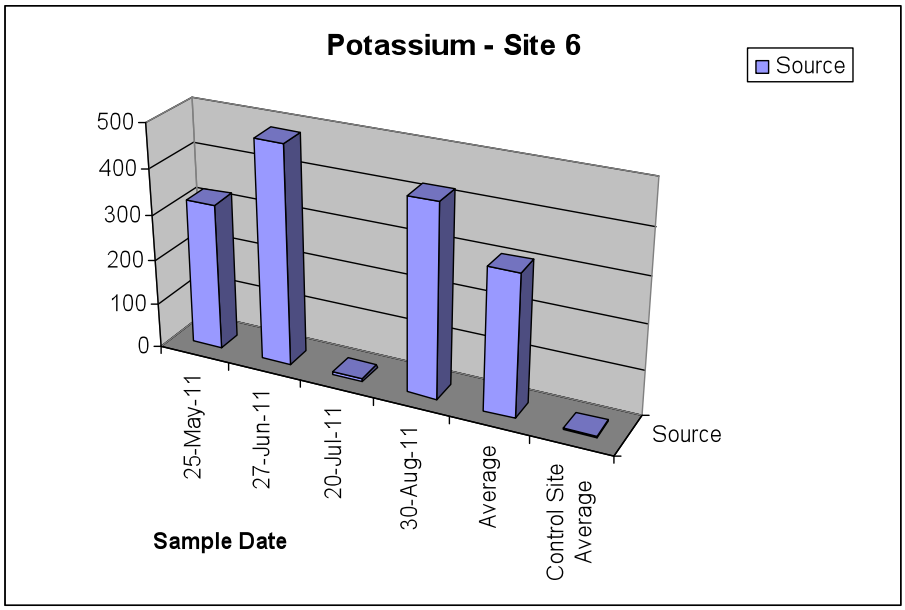
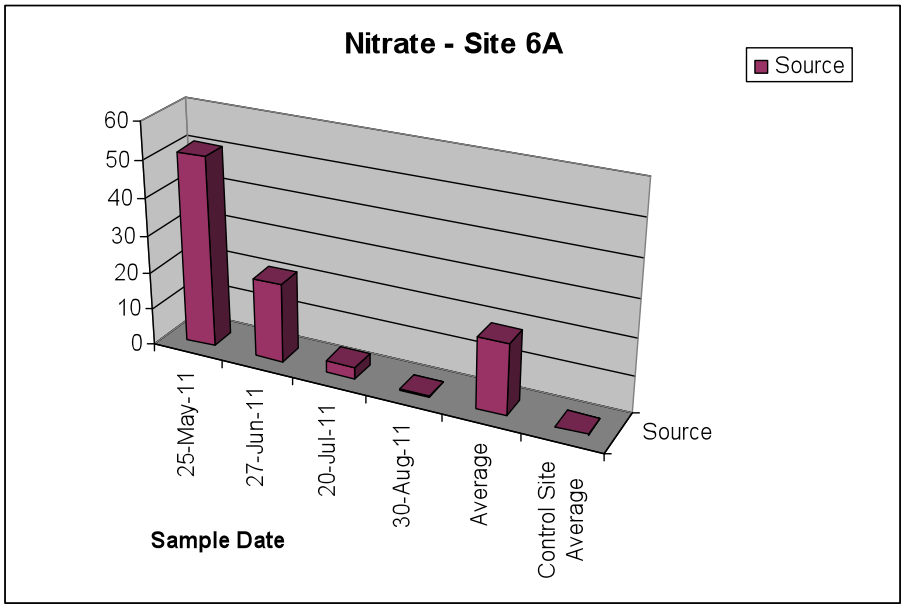


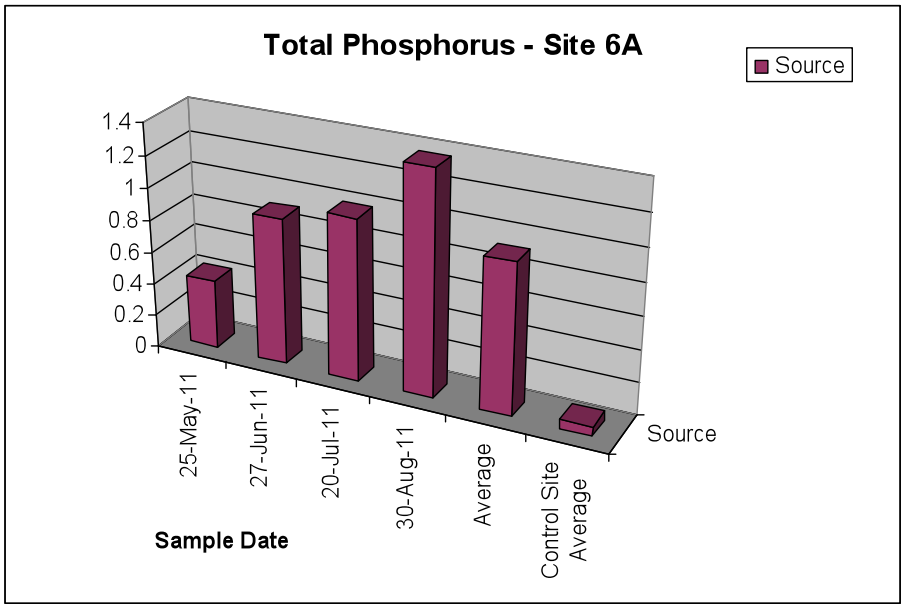
Figure 7: Nitrate, total phosphorus, and potassium concentrations at Site 6 on each of the four sampling days.

Samples were taken at the source only. Also shown is the concentration at the source averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





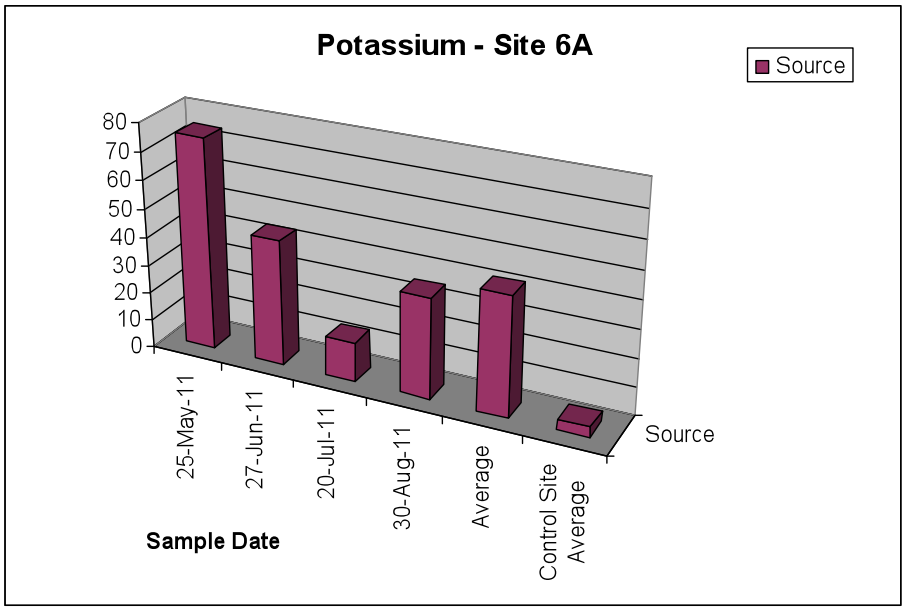
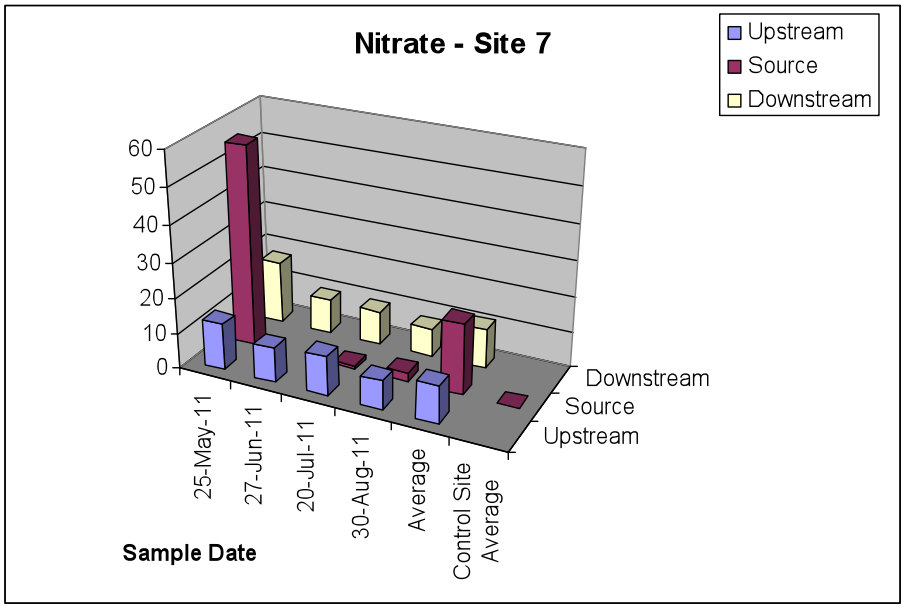


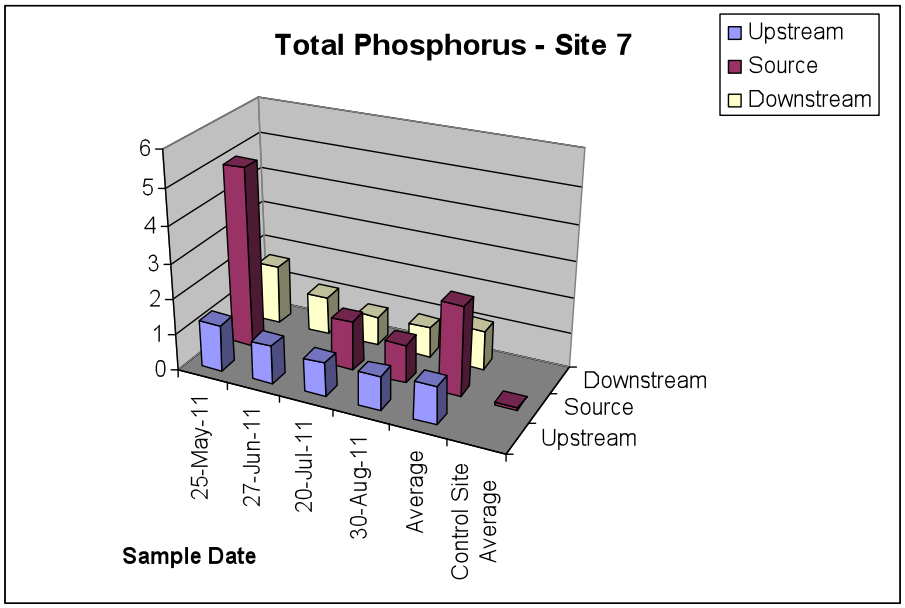
Figure 8: Nitrate, total phosphorus, and potassium concentrations at Site 6A on each of the four sampling days.

Samples were taken at the source only. Also shown is the concentration at the source averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





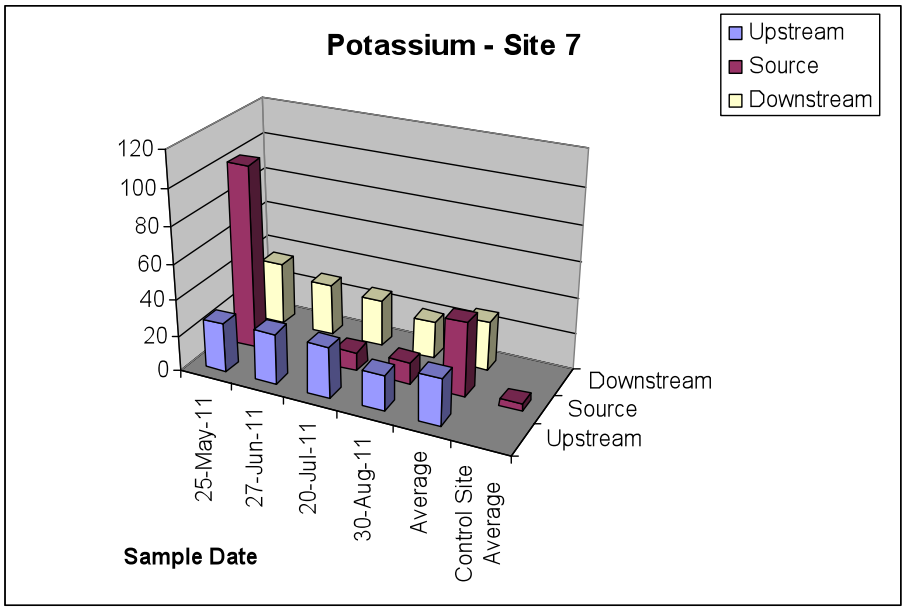


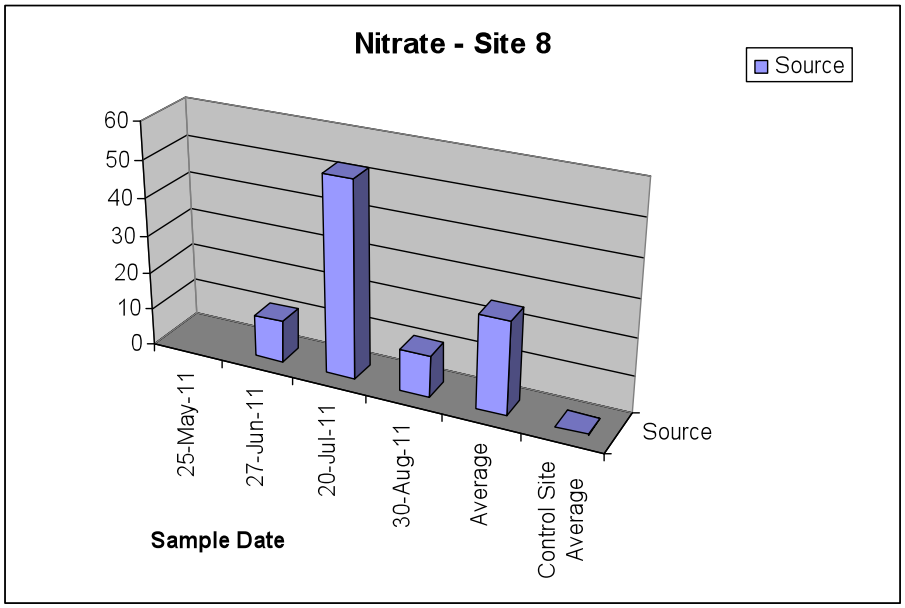
Figure 9: Nitrate, total phosphorus, and potassium concentrations at Site 7 on each of the four sampling days.

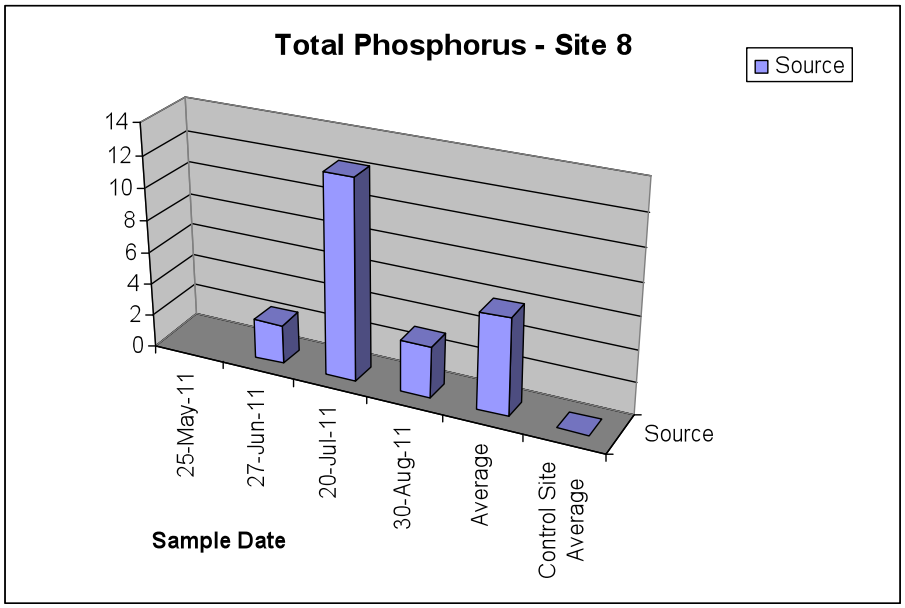
Samples were taken upstream, downstream, and at the source point. Shown also is the concentration at the upstream, source, and downstream locations averaged over the four sampling days.

Note that a source sample was not taken on June 27 (no flow observed).

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





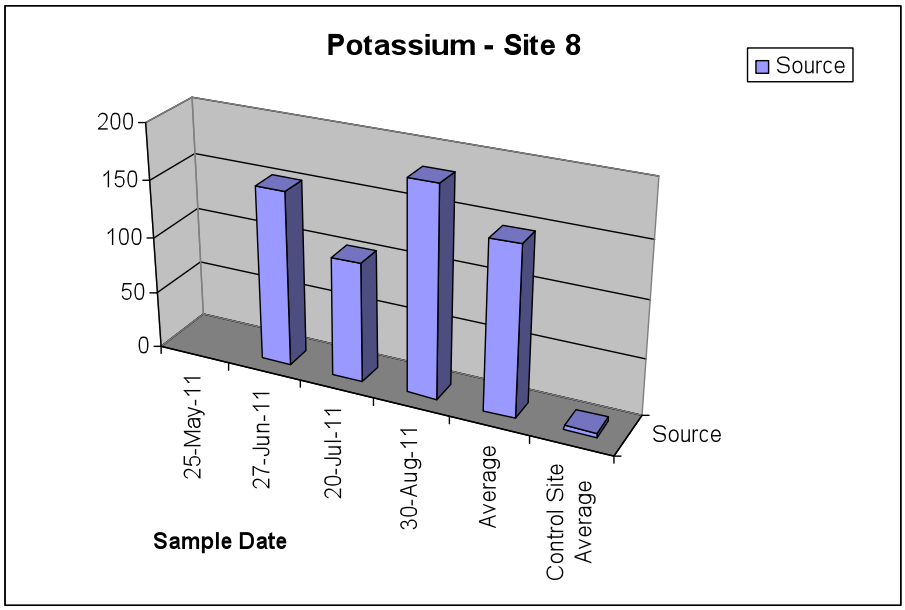
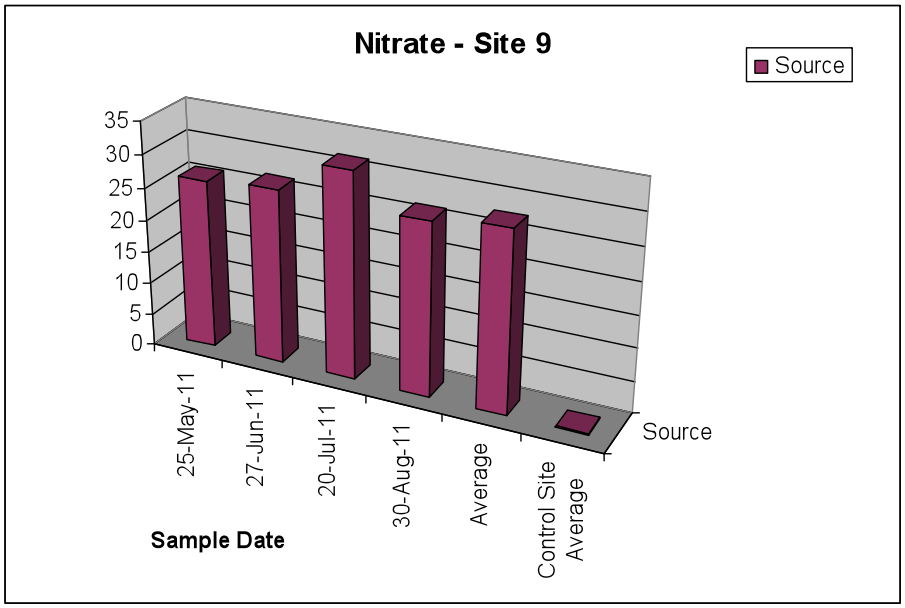


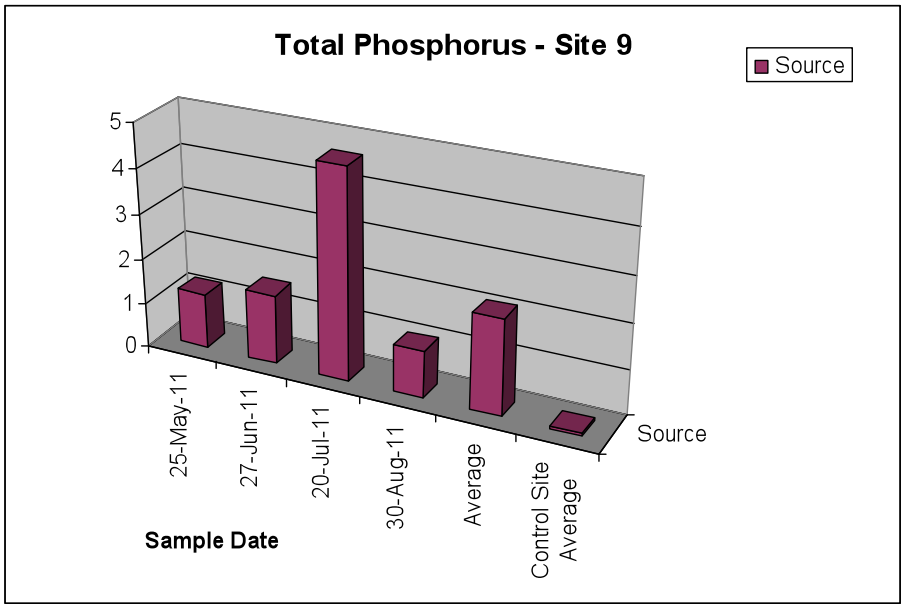
Figure 10: Nitrate, total phosphorus, and potassium concentrations at Site 8 on each of the three sampling days (no sample was taken on May 25).

Samples were taken at the source only. Also shown is the concentration at the source averaged over the three sampling days.

The control site concentrations, averaged over four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





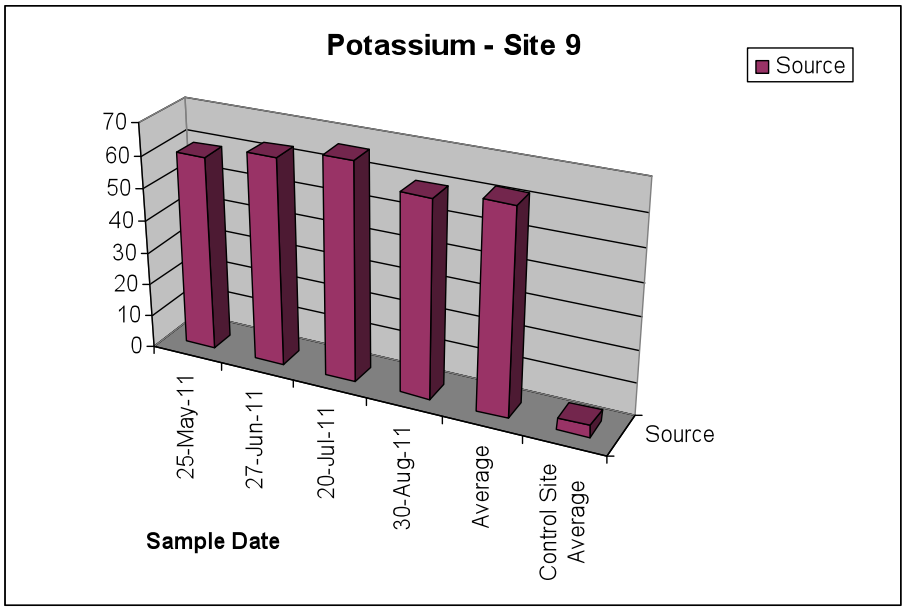
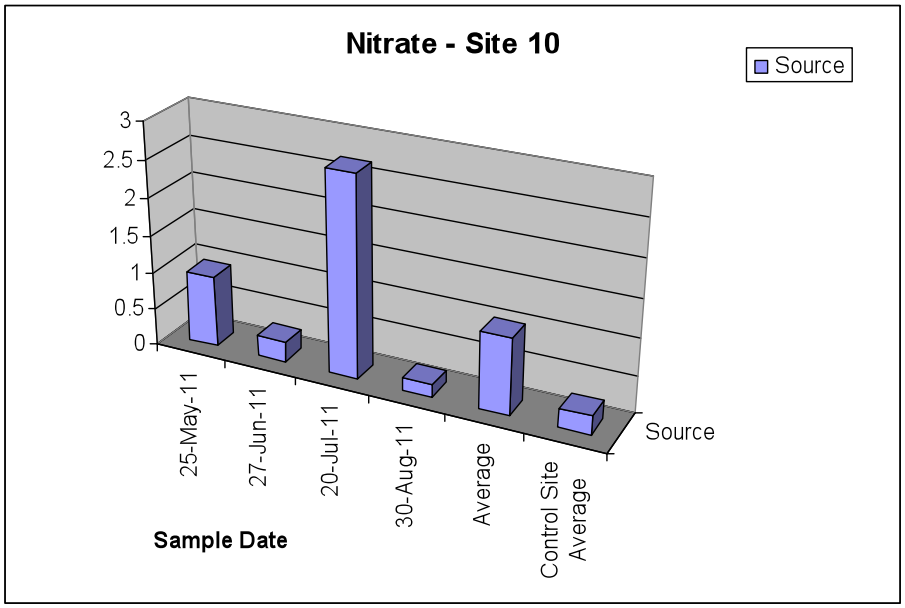


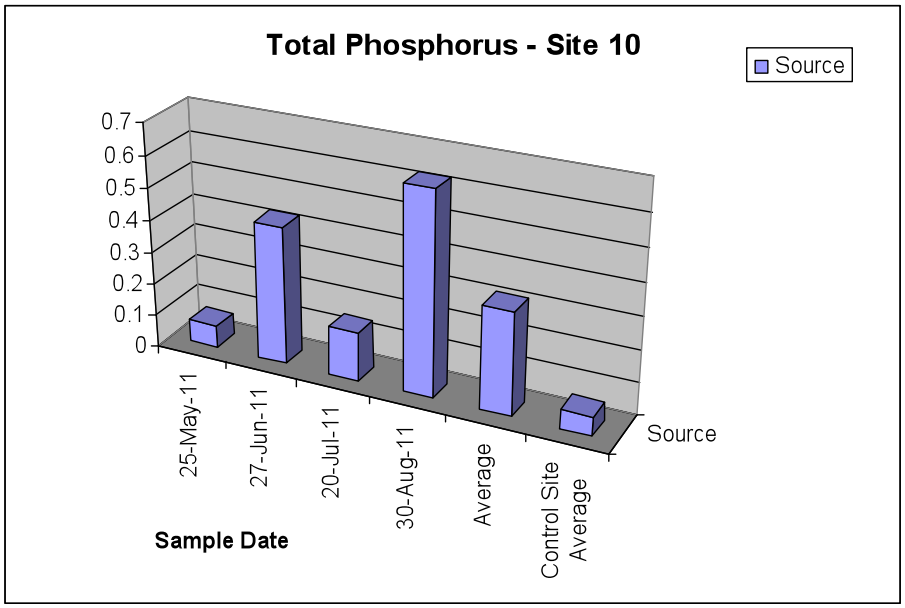
Figure 11: Nitrate, total phosphorus, and potassium concentrations at Site 9 on each of the four sampling days.

Samples were taken at the source only. Also shown is the concentration at the source averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





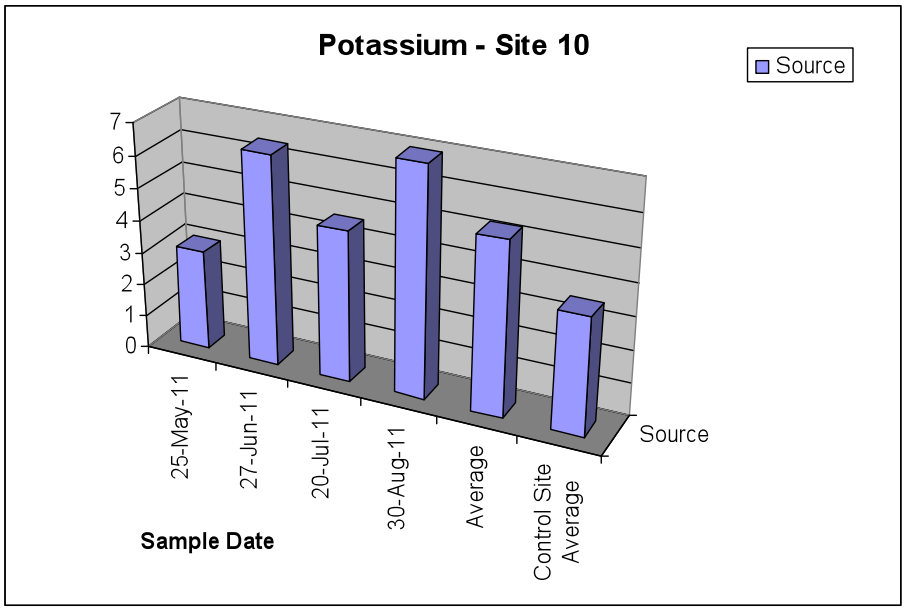
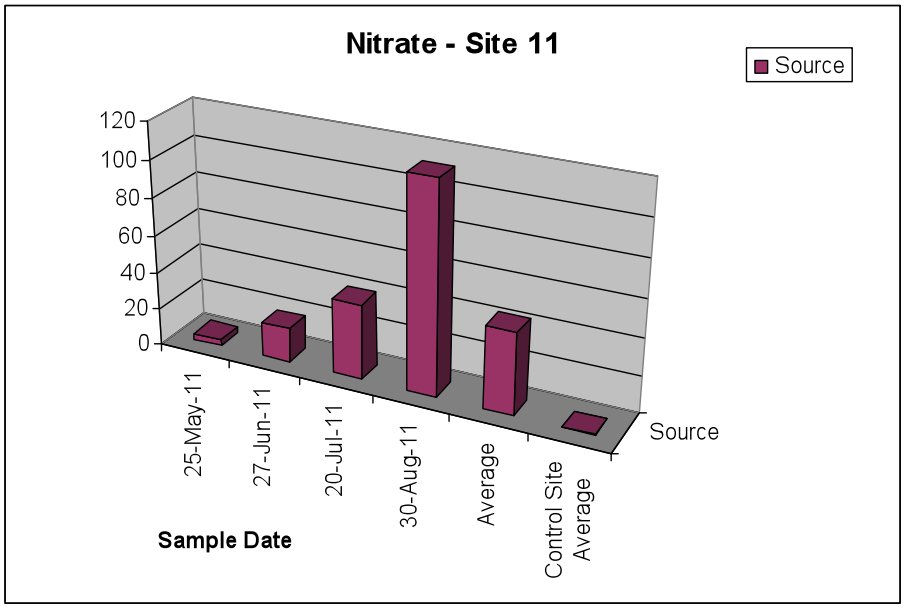


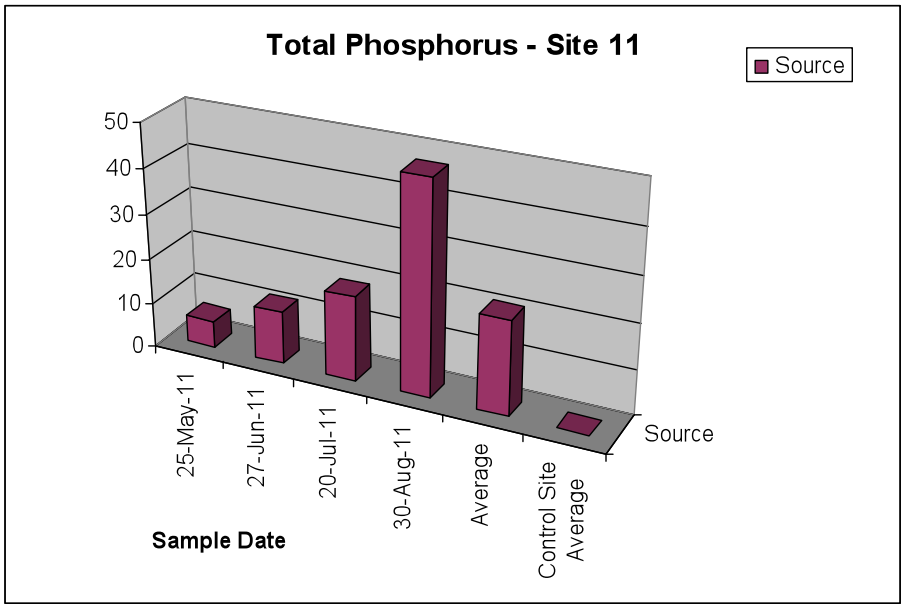
Figure 12: Nitrate, total phosphorus, and potassium concentrations at Site 10 on each of the four sampling days.

Samples were taken at the source only. Also shown is the concentration at the source averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





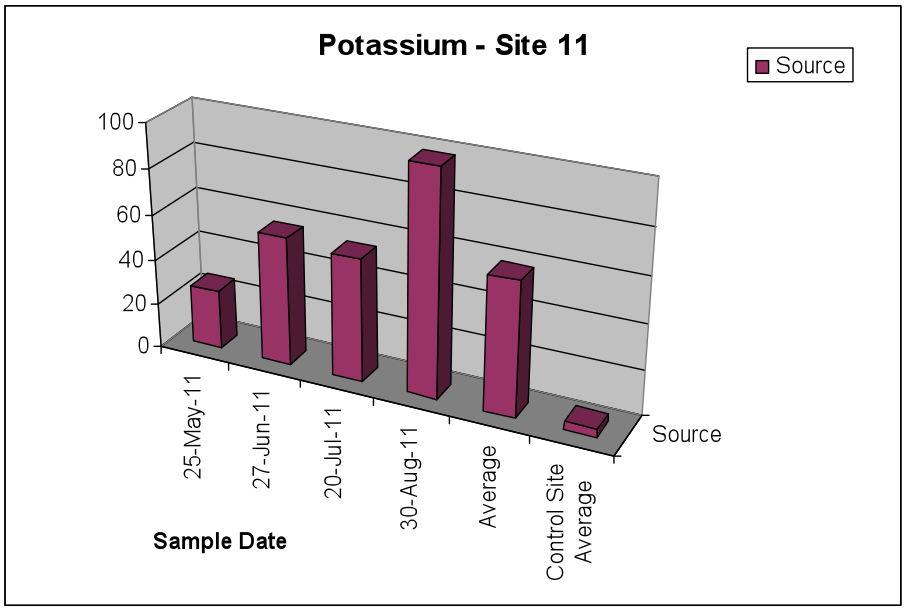
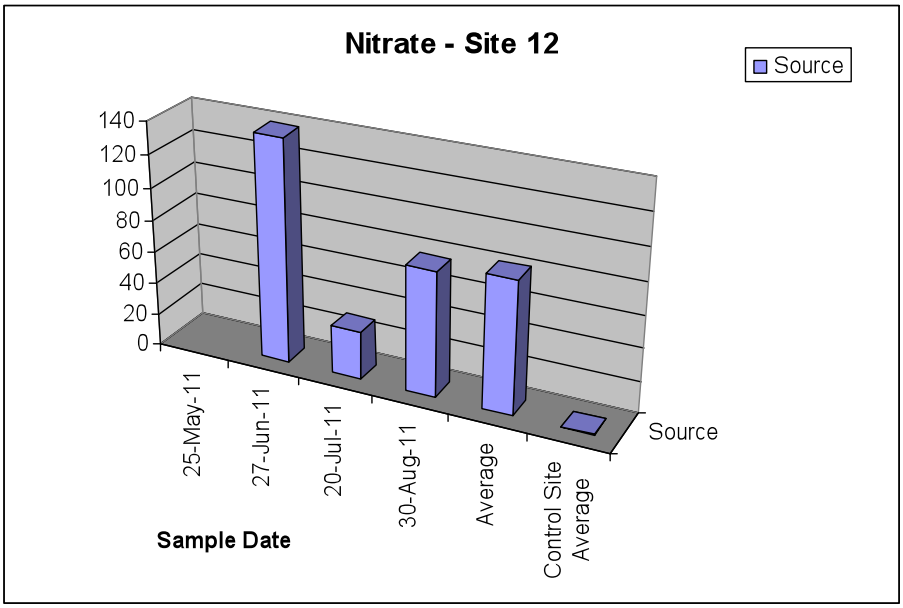


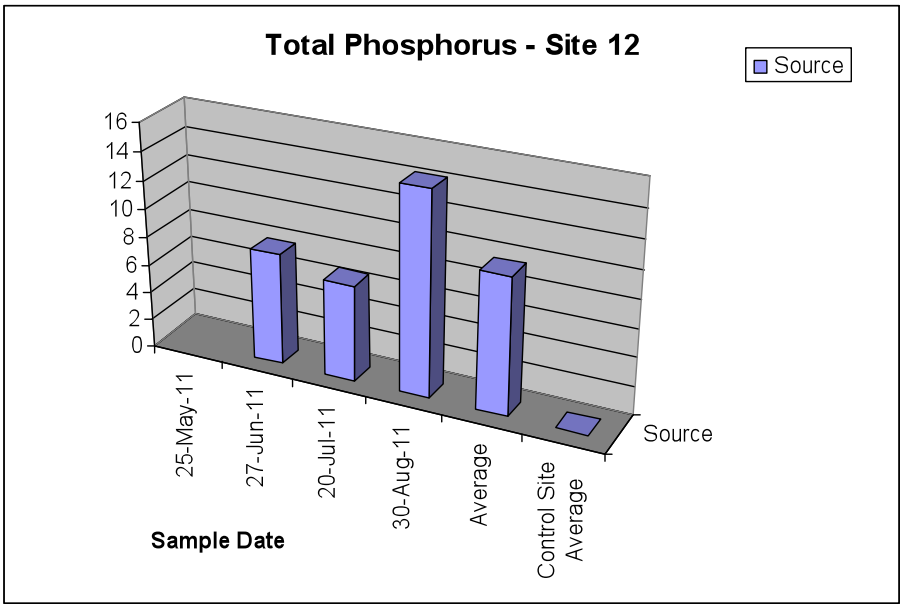
Figure 13: Nitrate, total phosphorus, and potassium concentrations at Site 11 on each of the four sampling days.

Samples were taken at the source only. Also shown is the concentration at the source averaged over the four sampling days.

The control site concentrations, averaged over the four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L





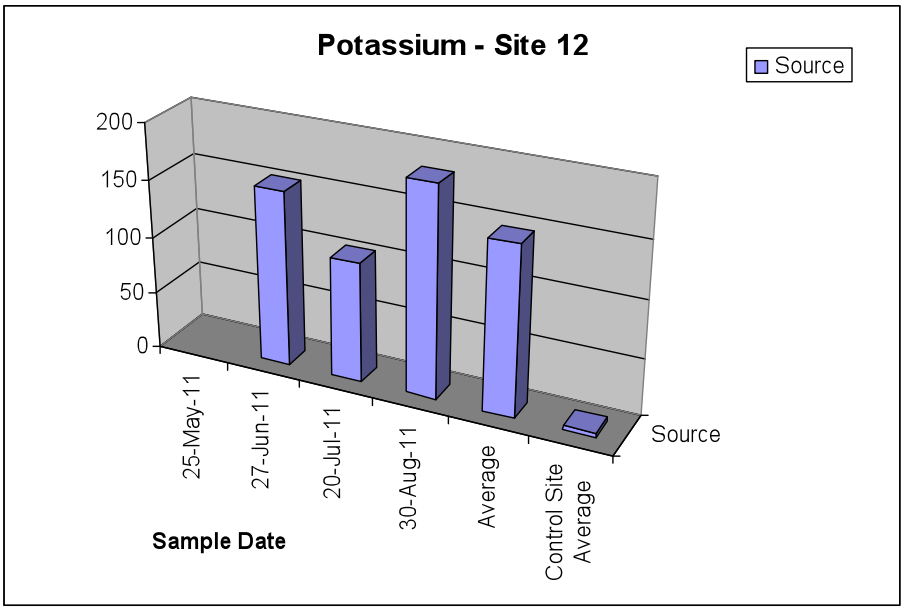


Figure 14: Nitrate, total phosphorus, and potassium concentrations at Site 12 on each of the three sampling days (no sample was taken on May 25).

Samples were taken at the source only. Also shown is the concentration at the source averaged over the three sampling days.

The control site concentrations, averaged over four sampling days are:

Nitrate: 0.25 mg/L
Phosphorus: 0.058 mg/L
Potassium: 3.6 mg/L

Leamington Study - Sampling Results - Site 01

		25-May-11	25-May-11	25-May-11	27-Jun-11	27-Jun-11	27-Jun-11	20-Jul-11	20-Jul-11	20-Jul-11	30-Aug-11	30-Aug-11	30-Aug-11
	Units	upstream	source	downstream	upstream	source	downstream	upstream	source	downstream	upstream	source	downstream
Conductivity	uS/cm	739	966	788	797	1350	1230	964	1610	1320	861	1560	1220
pH	none	8.29	8.19	8.28	8.49	8.12	8.23	8.52	8.24	8.31	8.1	7.91	7.96
Alkalinity, total fixed endpt	mg/L C	202	140	198	233	107	135	196	125	155	231	154	194
Nitrogen; nitrite	mg/L	0.138	0.169	0.151	0.136	0.249	0.247	0.933	0.383	0.627	0.734	0.083	0.439
Nitrogen; nitrate+nitrite	mg/L	6.5	36.3	11.7	0.57	79.5	61.3	11.1	97.8	56.3	5.66	84	47.5
Nitrogen; ammonia+ammonium	mg/L	0.44	0.4	0.43	4.69	0.19	1.19	1.38	0.2	0.95	2.63	0.05	1.61
Phosphorus; phosphate	mg/L	0.16	6.13	1.17	0.68	9.81	7.54	0.27	8.21	4.55	0.34	7.82	4
Nitrogen; total Kjeldahl	mg/L	1.58	1.23	1.59	4.86	0.2	1.61	1.98	1.48	0.98	4.7	1.38	3.2
Phosphorus; total	mg/L	0.25	6.53	1.43	0.69	10.4	5.75	0.4	8.58	5.03	0.49	7.88	4.36
Aluminum	ug/L	135	78.5	135	141	48.1	119	422	16.9	224	108	17	105
Barium	ug/L	46.4	17.8	44.1	40.1	13.7	20.7	62.5	19.2	37.7	52.9	20.8	37.5
Beryllium	ug/L	0	0	0	0	0.033	0	0.004	0	0	0	0.007	0.019
Calcium	mg/L	95.4	85	99.1	84.4	115	107	108	128	116	112	125	115
Cadmium	ug/L	0.175	0.396	0.187	0	0.112	0.217	0.06	0.753	0.464	0	0.53	0
Cobalt	ug/L	0.206	1.78	0.669	0.579	1.52	1.19	0.587	0.949	0.776	0	1.5	1.11
Chromium	ug/L	0	0	0	0	0	0.044	0	0	0	0	0	0
Copper	ug/L	4.34	59.4	13.8	3.47	179	141	11	178	101	5.06	209	111
Iron	ug/L	274	521	364	620	1490	1690	603	805	792	254	1030	1160
Magnesium	mg/l	21.8	21.9	22	20.1	28.6	27	24.1	36.4	30.8	21.8	34.6	28.6
Manganese	ug/L	67.6	61.2	75.4	148	74.6	95.8	93.9	38.1	61.7	73.3	28.2	55.1
Molybdenum	ug/L	5.83	6.26	7.07	9.5	4.73	3.93	12.9	7.41	8.62	7.83	6.62	6.53
Nickel	ug/L	2.61	18.3	5.54	3.15	12.4	11.8	6.01	13.7	10.3	2.69	19.6	11
Lead	ug/L	2.17	2.57	2.15	2.36	4.42	2.99	1.14	1.27	4.01	2.33	4.47	1.51
Potassium	mg/L	9.5	87.1	22.6	11.2	132	105	14.8	156	94.3	16.6	193	99
Sodium	mg/L	22.7	28.3	24.2	54.9	20.1	25.7	52.9	22	33.4	31.6	21.9	26.1
Strontium	ug/L	384	360	402	508	597	570	598	372	462	471	439	445
Titanium	ug/L	1.9	1.1	1.83	1.8	0	0.698	2.16	0.298	1.68	1.6	0.069	1.45
Vanadium	ug/L	2.93	10.8	4.8	4.76	8.07	8.07	5.86	9.6	8.07	4.56	13	8.9
Zinc	ug/L	14.5	368	76.1	12.9	485	393	23.2	583	393	22.5	578	315
Hardness	mg/L	327	302	338	294	405	378	369	465	416	369	455	405

Leamington Study - Sampling Results - Site 02

		25-May-11	25-May-11	25-May-11	27-Jun-11	27-Jun-11	27-Jun-11	20-Jul-11	20-Jul-11	20-Jul-11	30-Aug-11	30-Aug-11	30-Aug-11
	Units	Upstream	Source	Downstream	Upstream	Source	Downstream	Upstream	Source	Downstream	upstream	source	downstream
Conductivity	uS/cm	739	966	788	1590	3610	3210	1520	2360	1930	2290	3250	2410
pH	none	8.29	8.19	8.28	8.4	6.56	6.98	8.66	7.87	8.33	7.8	7.06	7.68
Alkalinity; total fixed endpt	mg/L C	202	140	198	223	60.8	97.2	177	80	135	182	88.3	167
Nitrogen; nitrite	mg/L	0.13	0.169	0.151	7.44	0.4	2.13	4.06	1.23	2.85	0.107	0.402	0.199
Nitrogen; nitrate+nitrite	mg/L	6.5	36.3	11.7	15.6	271	215	21.1	159	82.8	109	173	128
Nitrogen; ammonia+ammonium	mg/L	0.44	0.4	0.43	8.21	0.32	2.65	0.62	0.32	0.52	0.05	0.15	0.17
Phosphorus; phosphate	mg/L	0.16	6.13	1.17	0.88	95.5	74.9	0.4	16.5	8	20.8	29.7	22.7
Nitrogen; total Kjeldahl	mg/L	1.58	1.23	1.59	9.53	1.08	0.92	1.03	1.09	0.48	0.44	0.05	0.66
Phosphorus; total	mg/L	0.25	6.53	1.43	1.08	96	15.8	0.68	17.8	8.8	24.4	45.6	28
Aluminum	ug/L	135	78.5	135	367	59.7	863	228	16.8	208	60.5	150	69.8
Barium	ug/L	46.4	17.8	44.1	45	50.6	65.3	60.9	37.9	51.1	157	43.5	135
Beryllium	ug/L	0	0	0	0	0.06	0.104	0	0	0	0.03	0.08	0.037
Calcium	mg/L	95.4	85	99.1	101	390	336	112	243	169	240	366	266
Cadmium	ug/L	0.175	0.396	0.187	0.119	0.814	0.796	0.321	0.482	0.431	0.356	0.939	0.443
Cobalt	ug/L	0.206	1.78	0.659	0.509	0.847	2.44	0.008	1.4	0.465	0	1.89	0
Chromium	ug/L	0	0	0	0	0.28	1.13	0	0	0	0	0	0
Copper	ug/L	4.34	59.4	13.8	5.68	41.1	33.1	6	21.9	12.8	15.4	31.6	18.6
Iron	ug/L	274	521	364	528	580	1580	235	230	317	311	235	294
Magnesium	mg/l	21.6	21.9	22	27	65.5	58.1	26.6	44.9	34.2	46	70.2	51.3
Manganese	ug/L	67.6	61.2	75.4	38.5	197	252	18.2	75.2	50.2	16.3	98	36.5
Molybdenum	ug/L	5.83	6.26	7.07	13.7	38.4	29	18.3	86.8	46.3	13.8	132	179
Nickel	ug/L	2.61	18.3	5.54	5.48	9.04	11.4	5.22	13.2	8.22	6.75	20.5	10.6
Lead	ug/L	2.17	2.57	2.15	6.11	3.29	4.73	0	1.66	0	0	0	1.6
Potassium	mg/L	9.5	87.1	22.6	21.6	389	312	22.4	194	102	142	324	168
Sodium	mg/L	22.7	28.3	24.2	175	79.3	103	156	53	110	103	62.8	87.9
Strontium	ug/L	384	360	402	670	518	577	799	442	658	1760	806	1560
Titanium	ug/L	1.9	1.1	1.83	2.88	0	1.79	5.3	0	4.26	0.548	0.131	0
Vanadium	ug/L	2.93	10.8	4.8	9.28	5.58	8.72	6.98	4.91	6.52	6.84	5.22	6.26
Zinc	ug/L	14.5	368	76.1	11.7	852	670	11.1	399	179	155	405	217
Hardness	mg/L	327	302	338	363	1240	1080	389	792	563	789	1200	875

Leamington Study - Sampling Results - Site 2"A"

			25-May-11	27-Jun-11	20-Jul-11	30-Aug-11
	Units		Source	Source	Source	Source
Conductivity	uS/cm	-	1120	1120	5620	1430
pH	none	-	8.32	8.49	7.31	8.17
Alkalinity; total fixed endpt	mg/L CaCO3	-	291	229	44.6	226
Nitrogen; nitrite	mg/L	-	0.28	0.201	2.89	0.006
Nitrogen; nitrate+nitrite	mg/L		14.9	31.5	521	70.7
Nitrogen; ammonia+ammonium	mg/L	-	0.8	0.06	203	0.05
Phosphorus; phosphate	mg/L	-	0.33	3.1	12.2	2.08
Nitrogen; total Kjeldahl	mg/L	-	1.94	0.45	169	0.65
Phosphorus; total	mg/L	-	0.39	3.5	14.2	2.28
Aluminum	ug/L	-	59.9	32.4	866	71.3
Barium	ug/L	-	59.4	42.8	76.3	82.3
Beryllium	ug/L	-	0	0	0.111	0
Calcium	mg/L	-	144	137	385	189
Cadmium	ug/L	-	295	0	2.76	0
Cobalt	ug/L	-	0	0	4.36	0
Chromium	ug/L	-	0	0	4.84	0
Copper	ug/L	-	4.84	7.65	52.4	9.59
Iron	ug/L	-	189	65.6	1100	206
Magnesium	mg/l	-	37.3	34.7	90.7	44.4
Manganese	ug/L	-	58.7	6.77	970	18.2
Molybdenum	ug/L	-	72.3	1280	56.4	1270
Nickel	ug/L	-	5.47	9.32	34.7	16.6
Lead	ug/L	-	1.29	2.75	3.06	2.73
Potassium	mg/L	-	21.9	29.1	307	40
Sodium	mg/L	-	19.9	30.4	17.5	24.1
Strontium	ug/L	-	548	848	3330	722
Titanium	ug/L	-	1.44	0	4.46	0.059
Vanadium	ug/L	-	3.28	5.11	30	5.45
Zinc	ug/L	-	13	52.8	293	70.8
Hardness	mg/L	-	513	485	1330	655

Leamington Study - Sampling Results - Site 3 - Control Pond - Source only

			25-May-11	27-Jun-11	20-Jul-11	30-Aug-11
	Units		control	control	control	control
Conductivity	uS/cm	-	269	201	156	337
pH	none	-	8.07	9.54	8.45	8.45
Alkalinity; total fixed endpt	mg/L CaCO3	-	47.8	36.6	32.6	83.3
Nitrogen; nitrite	mg/L	-	0.016	0.009	0.009	0.061
Nitrogen; nitrate+nitrite	mg/L		0.28	0.1	0.05	0.67
Nitrogen; ammonia+ammonium	mg/L	-	0.07	0.05	0.05	0.53
Phosphorus; phosphate	mg/L	-	0.04	0.02	0.08	0.14
Nitrogen; total Kjeldahl	mg/L	-	0.72	0.45	2.87	1.43
Phosphorus; total	mg/L	-	0.02	0.02	0.15	0.04
Aluminum	ug/L	-	77.7	94.7	92.7	31.1
Barium	ug/L	-	4.53	2.1	10.6	32.3
Beryllium	ug/L	-	0	0	0	0
Calcium	mg/L	-	19.7	17.1	13.9	35.3
Cadmium	ug/L	-	0.004	0	0	0
Cobalt	ug/L	-	0.075	583	0.133	0
Chromium	ug/L	-	0	0.051	0	0
Copper	ug/L	-	2.85	2.13	2.07	1.47
Iron	ug/L	-	196	219	96.6	64.9
Magnesium	mg/l	-	1.15	1.37	1.39	4.01
Manganese	ug/L	-	23.2	16	13.2	20.3
Molybdenum	ug/L	-	2.01	4.77	2.49	4.51
Nickel	ug/L	-	1.3	1.53	0.956	1.77
Lead	ug/L	-	0.939	1.73	0	0.154
Potassium	mg/L	-	1.69	2.2	2.39	8.11
Sodium	mg/L	-	29.2	22.1	14.1	23.8
Strontium	ug/L	-	83.4	82.7	78.1	181
Titanium	ug/L	-	0.834	0.11	0.758	0.411
Vanadium	ug/L	-	2.21	3.23	2.3	2.58
Zinc	ug/L	-	3.63	2.52	2.4	3.28
Hardness	mg/L	-	54	48.4	40.4	105

Leamington Study - Sampling Results - Site #4

		25-May-11	25-May-11	May25 2011	27-Jun-11	27-Jun-11	June 27 201'	20-Jul-11	20-Jul-11	20-Jul-11	30-Aug-11	30-Aug-11	30-Aug-11
	Units	upstream	Source	downstream	upstream	Source	downstream	upstream	Source	downstream	upstream	source	downstream
Conductivity	uS/cm	853	586	830	994	548	1050	683	429	556	1140	536	1020
pH	none	8.51	9.16	8.5	8.43	9.22	8.39	8.42	8.6	8.34	8.01	10.2	8.12
Alkalinity; total fixed endpt	mg/L Ca	239	94.7	227	223	123	237	194	73.5	167	235	84	193
Nitrogen; nitrite	mg/L	0.029	0.213	0.04	0.068	0.17	0.067	0.121	0.384	0.036	0.069	0.595	0.207
Nitrogen; nitrate+nitrite	mg/L	10.5	6.44	9.87	25.8	3.95	28.3	9.38	7.12	5.53	32.1	11.8	28.8
Nitrogen; ammonia+ammonium	mg/L	0.06	0.37	0.09	0.11	0.25	0.06	0.16	0.24	0.07	0.05	0.08	0.23
Phosphorus; phosphate	mg/L	1.92	0.22	1.85	5.59	0.57	6.21	1.1	0.57	0.05	6.86	0.12	5.41
Nitrogen; total Kjeldahl	mg/L	0.93	2.19	1.11	0.98	2.22	1.92	1.02	2.27	0.74	1.05	4.05	7.1
Phosphorus; total	mg/L	2.21	0.89	2.19	6.08	1.11	6.85	1.32	1.03	0.12	6.88	0.54	7.25
Aluminum	ug/L	72.7	177	190	110	227	34	561	437	183	49.1	75.1	578
Barium	ug/L	44	19.5	45.3	41.5	18.7	44.5	50.8	28.3	70.3	63.5	27.2	67.2
Beryllium	ug/L	0	0.005	0.011	0.01	0	0	0.013	0	0	0	0	0.071
Calcium	mg/L	119	55.8	116	148	52.3	139	106	45.1	84.4	149	49.7	129
Cadmium	ug/L	0.341	0.35	0.271	0	0	0	0	0.064	0.138	0	0	0
Cobalt	ug/L	0.696	0.621	0.662	1.05	1.67	0.98	0.932	1.03	0	0.625	1.2	1.62
Chromium	ug/L	0	20.8	0.655	0	0	0	0.038	1.1	0	0	0	0.052
Copper	ug/L	4.89	13.6	6.01	15.8	4.06	9.84	8.73	7.71	7.1	10.1	5.26	12.6
Iron	ug/L	114	127	198	238	293	129	589	467	180	149	117	450
Magnesium	mg/l	21.9	15.8	21.9	26.1	18	26.6	18.6	12.6	14.4	29.6	15.3	28.1
Manganese	ug/L	27.4	19.1	58.7	61.7	28.9	59.1	101	29.2	118	74.3	12.4	177
Molybdenum	ug/L	10.4	31.4	10.5	27.4	61.6	16.8	11.2	39.5	11.4	17.8	57.9	23.1
Nickel	ug/L	5.51	4.74	5.36	6.78	9.32	5.91	5.08	6.87	3.47	7.17	8.05	9.31
Lead	ug/L	3.25	4.88	5.86	2.46	3.48	0.307	3.34	2.53	0	1.75	1.72	7.7
Potassium	mg/L	14.9	37.7	16.6	50.3	35.9	54.3	12.9	19.5	10.1	59.3	38.4	57.4
Sodium	mg/L	14	17.9	14.3	13.2	17.5	11.9	9.63	12.7	8.31	18.3	15.2	17.8
Strontium	ug/L	386	633	411	480	579	436	309	395	400	456	457	474
Titanium	ug/L	1.12	0.929	1.73	0	0	0	1.12	1.15	0.637	0	0.46	0.017
Vanadium	ug/L	3.19	4.2	3.7	5.96	8.64	4.95	5.12	5.41	3.88	4.81	7.63	6.78
Zinc	ug/L	27.8	23.5	33.2	86.9	24.8	86.9	23.1	21	8.64	89.8	14.4	88.8
Hardness	mg/L	387	204	380	477	205	457	341	165	270	494	187	438

Leamington Study - Sampling Results - Site #6

		25-May-11	25-May-11	May 25 2011	27-Jun-11	27-Jun-11	June 27 2011	20-Jul-11	20-Jul-11	20-Jul-11	30-Aug-11	30-Aug-11	30-Aug-11
	Units	upstream	Source	downstream	upstream	Source	downstream	upstream	Source	downstream	upstream	source	downstream
Conductivity	uS/cm	1980	1860	1910	1250	2460	1570	980	1790	975	3150	3330	3160
pH	none	7.62	8.08	7.72	8.44	7.84	8.3	8.32	8.18	8.37	6.35	6.91	6.41
Alkalinity; total fixed endpt	mg/L Ca	129	150	131	235	146	212	180	163	182	51.3	91.6	55.3
Nitrogen; nitrite	mg/L	0.208	0.198	0.222	0.174	0.127	0.163	0.352	0.296	0.363	0.131	0.11	0.124
Nitrogen; nitrate+nitrite	mg/L	108	86	106	19.7	183	61.6	29.4	113	28	213	300	183
Nitrogen; ammonia+ammonium	mg/L	0.43	0.1	0.4	0.41	0.05	0.34	0.68	0.16	0.63	0.2	0.05	0.17
Phosphorus; phosphate	mg/L	29.4	12	25.8	6.1	26.8	11.5	7.01	13.4	6	86.7	48	69.6
Nitrogen; total Kjeldahl	mg/L	0.35	0.3	0.05	1.04	0.7	0.44	1	0.89	1.23	1.39	0.05	0.72
Phosphorus; total	mg/L	26	11.4	25.9	6.78	28.5	12.8	7.45	14.3	6.4	84.8	53.6	85.5
Aluminum	ug/L	37.1	7.37	48	20.3	2.91	6.38	74.8	107	76.1	180	71.7	71
Barium	ug/L	31.5	54.4	33.9	22.1	172	60	36.9	187	46.8	57	320	76.8
Beryllium	ug/L	0.064	0.031	0.052	0	0	0	0	0	0	0.053	0.072	0.042
Calcium	mg/L	227	208	214	124	227	153	115	183	115	305	383	320
Cadmium	ug/L	0.099	0	0.419	0	0	0	0.154	0.11	0	0.567	0	0.829
Cobalt	ug/L	0.058	0.7	0	0	0	0	0	0.802	0	0	0	0
Chromium	ug/L	0	0	0	0	0	0	0	0	0	0	0	0
Copper	ug/L	48.5	22.6	44.3	13.2	28.8	17.4	15.3	20.6	11.8	102	54.8	94.4
Iron	ug/L	489	49.8	465	120	105	138	227	251	192	1160	500	969
Magnesium	mg/l	56.9	57.7	54.8	33.3	83.2	45.4	24	52.2	24.2	104	86.4	102
Manganese	ug/L	216	33.3	193	60.8	35.1	55	51.9	34.5	38.4	130	53.9	94.6
Molybdenum	ug/L	85	53.5	78.5	196	24.9	157	66.5	27.4	63.2	68.9	10.2	89.9
Nickel	ug/L	8.12	12.3	8.61	7.94	8.48	7.79	4.8	13.8	5.67	7.05	10.6	7.64
Lead	ug/L	3.09	0.809	2.87	2.67	0	2.92	0	0	1.18	0.038	0	0.236
Potassium	mg/L	135	109	128	71.5	206	104	39.5	113	42.1	348	282	342
Sodium	mg/L	37.5	51.6	38.3	48.4	37.4	41.2	25.8	30.3	25.8	36.6	31.3	35.8
Strontium	ug/L	2240	1430	2050	1670	2820	1910	1150	1770	1020	5830	4250	5690
Titanium	ug/L	0.197	0	0.429	0	0	0	0.844	0.468	0.908	0	0	0
Vanadium	ug/L	5.22	3.87	4.86	4.84	4.3	5.4	3.89	4.12	3.95	5.6	3.75	4.79
Zinc	ug/L	323	401	319	142	488	229	98.8	304	103	728	426	696
Hardness	mg/L	801	757	760	447	909	569	386	672	387	1190	1310	1220

Learnington Study - Sampling Results - Site # 6

			25-May-11		27-Jun-11		20-Jul-11		30-Aug-11	
	Units			Source		Source		Source		Source
Conductivity	uS/cm	-			4420		4170		603	4150
pH	none	-			6.27		5.97		9.52	5.53
Alkalinity; total fixed endpt	mg/L CaCO3	-			32.6		28.2		127	10.3
Nitrogen; nitrite	mg/L	-			0.257		0.243		0.185	0.179
Nitrogen; nitrate+nitrite	mg/L				432		283		2.76	287
Nitrogen; ammonia+ammonium	mg/L	-			6.43		1.41		1.16	1.32
Phosphorus; phosphate	mg/L	-			53.2		104		0.98	78.8
Nitrogen; total Kjeldahl	mg/L	-			1.46		0.05		2	1.75
Phosphorus; total	mg/L	-			42.7		109		1.16	107
Aluminum	ug/L	-			28.2		18		283	32.4
Barium	ug/L	-			58.5		52.8		6.2	46.7
Beryllium	ug/L	-			0.125		0.069		0	0.117
Calcium	mg/L	-			606		444		13.6	461
Cadmium	ug/L	-			0.023		1.19		0	1.11
Cobalt	ug/L	-			0.34		0		0	0
Chromium	ug/L	-			0		0		0	0
Copper	ug/L	-			71.9		53.3		11.7	61.4
Iron	ug/L	-			1890		751		181	1090
Magnesium	mg/l	-			69.7		103		3.53	103
Manganese	ug/L	-			1280		370		29.7	495
Molybdenum	ug/L	-			26.1		19.7		597	7.45
Nickel	ug/L	-			0.789		1.62		3.12	3.01
Lead	ug/L	-			7.63		1.07		2.34	0
Potassium	mg/L	-			325		485		7.25	424
Sodium	mg/L	-			36.2		38.1		117	38.6
Strontium	ug/L	-			3960		2020		178	874
Titanium	ug/L	-			0		0		1.3	0
Vanadium	ug/L	-			11.3		3.32		2.42	3.84
Zinc	ug/L	-			682		601		51.2	710
Hardness	mg/L	-			1800		1530		48.4	1580

Leamington Study - Sampling Results - Site # 6A

			25-May-11	27-Jun-11	20-Jul-11	30-Aug-11
	Units		Source	Source	Source	Source
Conductivity	uS/cm	-	1010	841	364	501
pH	none	-	8.7	9.07	8.23	9.27
Alkalinity; total fixed endpt	mg/L CaCO3	-	61	93	65.2	130
Nitrogen; nitrite	mg/L	-	1.04	1.66	0.19	0.282
Nitrogen; nitrate+nitrite	mg/L		52.3	23	3.45	0.62
Nitrogen; ammonia+ammonium	mg/L	-	0.2	0.14	0.28	0.61
Phosphorus; phosphate	mg/L	-	0.5	0.39	0.72	0.66
Nitrogen; total Kjeldahl	mg/L	-	0.11	0.58	0.96	4.23
Phosphorus; total	mg/L	-	0.43	0.91	1	1.38
Aluminum	ug/L	-	37.3	96.3	677	98.7
Barium	ug/L	-	17.2	17.4	26.5	14.8
Beryllium	ug/L	-	0	0	0.016	0
Calcium	mg/L	-	98	85.8	40.9	52.6
Cadmium	ug/L	-	0.212	0.34	0.1	0
Cobalt	ug/L	-	0	0	0	1.19
Chromium	ug/L	-	0	0	0.166	0
Copper	ug/L	-	10.7	7.48	5.04	3.87
Iron	ug/L	-	67.7	26.8	527	105
Magnesium	mg/l	-	15.6	13.9	6.21	9.65
Manganese	ug/L	-	9.17	15.1	91	70.6
Molybdenum	ug/L	-	154	265	240	45.4
Nickel	ug/L	-	3.03	3.27	3.65	4.11
Lead	ug/L	-	2.98	1.32	0.173	2.88
Potassium	mg/L	-	74.9	44.4	13.8	35.7
Sodium	mg/L	-	23.9	37.1	16.6	21.9
Strontium	ug/L	-	873	844	532	455
Titanium	ug/L	-	0.244	0	0.924	0.681
Vanadium	ug/L	-	3.63	4.34	3.51	5.13
Zinc	ug/L	-	33.1	11.9	10.4	12.2
Hardness	mg/L	-	309	271	128	171

Leamington Study- Sampling Results - Site #7 -

		25-May-11	25-May-11	May 25 2011	27-Jun-11	27-Jun-11	June 27 2011	20-Jul-11	20-Jul-11	20-Jul-11	30-Aug-11	30-Aug-11	30-Aug-11
	Units	upstream	Source	downstream	upstream	Source	downstream	upstream	Source	downstream	upstream	source	downstream
Conductivity	uS/cm	1430	1620	1450	1150	N	1150	1090	811	1080	1040	745	1040
pH	none	8.45	8.29	8.41	8.66	O	8.66	8.49	8.62	8.52	8.25	8.7	8.24
Alkalinity; total fixed endpt	mg/L CaCO3	266	246	259	272		272	252	342	254	274	280	276
Nitrogen; nitrite	mg/L	0.217	0.757	0.268	0.161	S	0.161	0.261	0.031	0.251	0.093	0.006	0.092
Nitrogen; nitrate+nitrite	mg/L	13.2	57	17.8	9.87	A	9.87	11.2	0.93	9.69	8.12	2.46	8.01
Nitrogen; ammonia+ammonium	mg/L	0.36	1.26	0.43	0.1	M	0.1	0.27	0.17	0.23	0.07	0.05	0.09
Phosphorus; phosphate	mg/L	1.05	4.33	1.42	0.95	P	0.95	0.74	1.12	0.65	0.71	0.85	0.69
Nitrogen; total Kjeldahl	mg/L	0.86	1.23	1.05	0.47	L	0.47	0.93	1.15	0.9	0.46	1.37	0.54
Phosphorus; total	mg/L	1.3	5.05	1.68	1.07	E	1.07	0.95	1.38	0.83	0.94	1.07	0.85
Aluminum	ug/L	42	37.3	47.3	37.7		37.7	33	3.51	26.2	11.1	84.3	8.48
Barium	ug/L	82.4	63.7	82.1	60.2	T	60.2	81.4	71.6	82.6	58	34.7	59.3
Beryllium	ug/L	0	0.045	0	0	A	0	0	0	0	0	0	0
Calcium	mg/L	132	205	138	133	K	133	121	147	121	127	108	128
Cadmium	ug/L	0.155	0	0.177	0	E	0	0	0	0	0	0	0
Cobalt	ug/L	0.567	1.26	0.368	0.848	N	0.848	0.891	0.201	0.489	0.235	0	0.036
Chromium	ug/L	0	0	0	0		0	0	0.06	0	0	0	0
Copper	ug/L	4.52	10.6	5.31	6.59	N	6.59	6.71	2.45	6.37	4.43	5.03	4.28
Iron	ug/L	397	446	465	629	O	629	326	1130	335	375	233	359
Magnesium	mg/l	41	41.4	41.7	25.6		25.6	20.1	19.4	19.7	26.5	17	26.6
Manganese	ug/L	127	212	133	52.4	F	52.4	77	284	77.5	45.2	29.7	45.5
Molybdenum	ug/L	29.3	31.9	28.4	27.3	L	27.3	25.9	10.7	24.8	15	14	14.5
Nickel	ug/L	8.31	26.9	9.09	12.2	O	12.2	15	7.53	13.7	8.97	5.46	8.71
Lead	ug/L	2.19	0.505	2.88	0.998	W	0.998	0	0	1.34	0.155	0.509	0
Potassium	mg/L	27.1	102	35.3	28.4		28.4	28	10.5	26.3	20.1	11.7	20.4
Sodium	mg/L	95.4	27.3	86.5	71.2		71.2	66.6	11.1	67.8	46.1	31.8	44.9
Strontium	ug/L	902	614	882	741		741	749	481	768	570	600	575
Titanium	ug/L	0.513	0.125	0.716	0		0	0.575	0	0.407	0	0.631	0
Vanadium	ug/L	6.61	30.4	9.87	22.4		22.4	7.81	3.52	7.52	7.15	8.44	7
Zinc	ug/L	38.4	92.3	38.4	28.1		28.1	15.8	23.2	14.4	21.3	41.6	20.2
Hardness	mg/L	498	682	516	438		438	385	447	383	426	340	429

Leamington Study - Sampling Results - Site # 8

			25-May-11		27-Jun-11	20-Jul-11	30-Aug-11
	Units		Source		Source	Source	Source
Conductivity	uS/cm	-		N	828	1200	941
pH	none	-		O	9.21	8.19	8.95
Alkalinity; total fixed endpt	mg/L CaCO3	-			128	88.1	150
Nitrogen; nitrite	mg/L	-		S	0.321	0.445	0.141
Nitrogen; nitrate+nitrite	mg/L			A	11.7	53	11.1
Nitrogen; ammonia+ammonium	mg/L	-		M	0.13	0.07	0.06
Phosphorus; phosphate	mg/L	-		P	0.9	10.5	2.31
Nitrogen; total Kjeldahl	mg/L	-		L	1.97	0.18	0.75
Phosphorus; total	mg/L	-		E	2.45	12.4	3.19
Aluminum	ug/L	-			26.8	73.9	1.82
Barium	ug/L	-		T	37.5	44.8	35.7
Beryllium	ug/L	-		A	0	0	0.002
Calcium	mg/L	-		K	78.4	103	86.4
Cadmium	ug/L	-		E	0	0	0
Cobalt	ug/L	-		N	1.07	0.341	0.025
Chromium	ug/L	-			0	0	0
Copper	ug/L	-		N	28.8	140	17.6
Iron	ug/L	-		O	409	222	45.5
Magnesium	mg/l	-			21.8	36.9	28.4
Manganese	ug/L	-		A	30.6	20.8	5.32
Molybdenum	ug/L	-		C	20.4	37.7	23.7
Nickel	ug/L	-		C	4.83	6.91	6.31
Lead	ug/L	-		E	3.46	0	0.094
Potassium	mg/L	-		S	71.9	101	62.7
Sodium	mg/L	-		S	27	19.7	35.3
Strontium	ug/L	-			269	394	256
Titanium	ug/L	-			0	0.104	0
Vanadium	ug/L	-			4.3	3.7	3.52
Zinc	ug/L	-			90.7	99	44.9
Hardness	mg/L	-			286	409	333

Leamington Study - Sampling Results - Site # 9

	Units		25-May-11 Source	27-Jun-11 Source	20-Jul-11 Source	30-Aug-11 Source
Conductivity	uS/cm	-	1320	1370	1220	1500
pH	none	-	8.41	8.49	8.38	8.65
Alkalinity; total fixed endpt	mg/L CaCO3	-	255	271	216	266
Nitrogen; nitrite	mg/L	-	0.229	0.246	0.601	0.369
Nitrogen; nitrate+nitrite	mg/L		26.4	27.3	32.5	27.1
Nitrogen; ammonia+ammonium	mg/L	-	0.46	0.39	3.09	0.17
Phosphorus; phosphate	mg/L	-	1.04	1.38	4.34	0.74
Nitrogen; total Kjeldahl	mg/L	-	0.61	0.72	3.22	1.13
Phosphorus; total	mg/L	-	1.22	1.55	4.67	1.04
Aluminum	ug/L	-	41.9	24.4	108	337
Barium	ug/L	-	67	71.6	65.8	82.9
Beryllium	ug/L	-	0	0.015	0	0
Calcium	mg/L	-	157	166	141	162
Cadmium	ug/L	-	0.274	0	0.507	0
Cobalt	ug/L	-	1.97	2.28	1.86	0
Chromium	ug/L	-	0	0	0	0
Copper	ug/L	-	12.4	11.7	48.5	40.7
Iron	ug/L	-	206	153	333	272
Magnesium	mg/l	-	29.2	31.4	27.8	34.3
Manganese	ug/L	-	218	168	216	115
Molybdenum	ug/L	-	40.6	46.2	31.6	21400
Nickel	ug/L	-	25.3	26.2	22.2	80.6
Lead	ug/L	-	2.18	2.71	0	15.1
Potassium	mg/L	-	59.8	63.7	66.9	60.4
Sodium	mg/L	-	34.3	41.7	26.8	105
Strontium	ug/L	-	476	481	419	474
Titanium	ug/L	-	0.264	0	2.07	0
Vanadium	ug/L	-	3.12	4.24	4.49	0
Zinc	ug/L	-	46.9	34.5	85.1	24.4
Hardness	mg/L	-	512	544	467	546

Leamington Study - Sampling Results - Site # 10

			25-May-11	27-Jun-11	20-Jul-11	30-Aug-11
	Units		Source	Source	Source	Source
Conductivity	uS/cm	-	570	670	639	581
pH	none	-	8.36	8.33	8.48	8.15
Alkalinity; total fixed endpt	mg/L CaCO3	-	184	237	177	209
Nitrogen; nitrite	mg/L	-	0.06	0.04	0.05	0.156
Nitrogen; nitrate+nitrite	mg/L		1.02	0.32	2.75	0.33
Nitrogen; ammonia+ammonium	mg/L	-	0.34	0.05	0.2	0.08
Phosphorus; phosphate	mg/L	-	0.02	0.32	0.1	0.46
Nitrogen; total Kjeldahl	mg/L	-	0.59	0.58	0.28	7.36
Phosphorus; total	mg/L	-	0.07	0.43	0.15	0.63
Aluminum	ug/L	-	8.6	11	27.4	8.27
Barium	ug/L	-	177	164	183	207
Beryllium	ug/L	-	0	0	0	0.001
Calcium	mg/L	-	78.1	104	89.6	82.7
Cadmium	ug/L	-	0	0	0	0
Cobalt	ug/L	-	0	0.547	0.132	0
Chromium	ug/L	-	0	0	0	0
Copper	ug/L	-	2.25	2.35	2.2	1.39
Iron	ug/L	-	812	731	288	311
Magnesium	mg/l	-	18.4	25.2	21.3	22.9
Manganese	ug/L	-	28.8	400	62.8	57.3
Molybdenum	ug/L	-	2.72	2.24	4.87	1.06
Nickel	ug/L	-	0.915	2.95	1.64	1.46
Lead	ug/L	-	0	0	0	1.05
Potassium	mg/L	-	3.08	6.47	4.63	7
Sodium	mg/L	-	14.4	11.2	17.5	10.9
Strontium	ug/L	-	1730	1950	2450	2480
Titanium	ug/L	-	0.045	0	0.293	0
Vanadium	ug/L	-	2.48	3.1	3.33	3.56
Zinc	ug/L	-	51.3	27.8	13	20.9
Hardness	mg/L	-	271	363	311	301

Leamington Study - Sampling Results - Site # 11

	Units		25-May-11 Source	27-Jun-11 Source	20-Jul-11 Source	Aug-30 Source
Conductivity	uS/cm	-	465	730	1040	1720
pH	none	-	8.13	7.92	7.96	6.91
Alkalinity; total fixed endpt	mg/L CaCO3	-	130	139	139	80.8
Nitrogen; nitrite	mg/L	-	0.182	0.327	0.152	0.139
Nitrogen; nitrate+nitrite	mg/L		3.73	19.1	40.6	113
Nitrogen; ammonia+ammonium	mg/L	-	0.15	0.27	0.05	0.05
Phosphorus; phosphate	mg/L	-	5.6	10.4	17.6	45
Nitrogen; total Kjeldahl	mg/L	-	0.77	0.99	0.78	0.53
Phosphorus; total	mg/L	-	5.97	11.7	18.8	47.4
Aluminum	ug/L	-	89.1	8.27	5.35	28.5
Barium	ug/L	-	17.6	19.5	6.89	22
Beryllium	ug/L	-	0	0	0	0.025
Calcium	mg/L	-	63.3	85.6	134	206
Cadmium	ug/L	-	0.051	0	137	0
Cobalt	ug/L	-	0.341	0.762	1.59	0.479
Chromium	ug/L	-	0	0	0	0
Copper	ug/L	-	2.53	1.87	5.5	9.36
Iron	ug/L	-	282	79.6	127	262
Magnesium	mg/l	-	9.76	14.6	23.8	33.4
Manganese	ug/L	-	102	99.8	88.1	70.2
Molybdenum	ug/L	-	14.4	11.4	19.3	11.7
Nickel	ug/L	-	2.21	3.34	10.1	5.55
Lead	ug/L	-	1.51	0.977	0	3.29
Potassium	mg/L	-	26.1	56.8	54.1	99
Sodium	mg/L	-	6.65	10.2	13.6	19.9
Strontium	ug/L	-	531	650	521	816
Titanium	ug/L	-	1.06	0	0	0
Vanadium	ug/L	-	2.5	2.87	9.71	11.7
Zinc	ug/L	-	108	141	205	289
Hardness	mg/L	-	198	274	433	652

Leamington Study - Sampling Results - Site # 12

				25-May-11	27-Jun-11	20-Jul-11	30-Aug-11
	Units		Source	Source	Source	Source	Source
Conductivity	uS/cm	-	N		1400	1050	1620
pH	none	-	O		8.2	8.32	7.87
Alkalinity; total fixed endpt	mg/L CaCO3	-			200	227	234
Nitrogen; nitrite	mg/L	-	S		0.038	0.145	0.037
Nitrogen; nitrate+nitrite	mg/L		A		139	30	77.3
Nitrogen; ammonia+ammonium	mg/L	-	M		0.05	0.05	0.05
Phosphorus; phosphate	mg/L	-	P		7.5	6.48	10.9
Nitrogen; total Kjeldahl	mg/L	-	L		0.53	1.12	0.53
Phosphorus; total	mg/L	-	E		7.88	6.75	14.4
Aluminum	ug/L	-			21.6	27	17.7
Barium	ug/L	-	N		19.6	17.1	18.6
Beryllium	ug/L	-	O		0	0	0
Calcium	mg/L	-			111	99.8	135
Cadmium	ug/L	-	A		0	0	0
Cobalt	ug/L	-	C		931	0.781	0.098
Chromium	ug/L	-	C		0	0	0
Copper	ug/L	-	E		10.3	8.62	11.8
Iron	ug/L	-	S		241	255	259
Magnesium	mg/l	-	S		30.7	25.3	41.6
Manganese	ug/L	-			102	108	69.2
Molybdenum	ug/L	-			161	111	254
Nickel	ug/L	-			16.6	15.7	16
Lead	ug/L	-			1.32	2.5	0
Potassium	mg/L	-			154	105	184
Sodium	mg/L	-			29.6	16.4	35
Strontium	ug/L	-			367	384	380
Titanium	ug/L	-			0	0.494	0
Vanadium	ug/L	-			14.9	14	15.9
Zinc	ug/L	-			404	248	422
Hardness	mg/L	-			404	353	508

Ontario